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Substitutes for Corn for Growing and Fattening Pigs

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SUBSTITUTES FOR CORN FOR GROWING AND FATTENING PIGS

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INTRODUCTION

Although used less extensively than corn, a number of small grains and manufacturing and grain milling by-products, as well as materials which otherwise would have low or no market value, can be utilized satisfactorily in the feeding of swine. Savings in the cost of production can sometimes be brought about, particularly if it is necessary to purchase carbonaceous feeds and if corn is scarce and high priced, by knowing the comparative worth of feeds that may be used to replace a part or all of the corn in the ration and methods of utilizing them to the best advantage. The experiments herein reported were conducted to secure information on various feeds as complete or partial substitutes for corn in swine feeding.

PRICES USED

In making calculations in which the prices of feeds were involved, the following schedule was used:

SCHEDULE OF PRICES USED

Barley	$ 0.54	bu.
Ear corn	.60	bu.
Oats	.36	bu.
Rye	.65	bu.
Wheat	.90	bu.
Cocoa bean oil meal	18.00	ton
Cocoanut oil meal	30.00	ton
Corn distillers' dried grains	20.00	ton
Corn germ meal	25.00	ton
Corn oil meal	25.00	ton
Hominy feed	24.50	ton
Hulled oats	39.00	ton
Molasses	30.00	ton
Oat hulls	15.00	ton
Oat middlings	36.00	ton
"Palmo Midds"	24.00	ton
Rice bran	24.00	ton
Rice pearling cone bran	28.00	ton
Rice polish	30.00	ton
Wheat middlings, standard	24.00	ton
Wheat middlings, flour	28.00	ton
Cottonseed meal	28.00	ton
Linseed meal	30.00	ton
Tankage	45.00	ton
Meat and bone scraps	37.50	ton
Ground alfalfa	18.00	ton
Minerals	40.00	ton
Skimmed milk	.225	cwt.
Grinding grain, except oats	.10	cwt.
Grinding oats	.15	cwt.
Shelling corn	.03	bu.

In the experiments reported or referred to, the corn substitutes were compared with ground corn in some instances and with shelled corn in others. To combine the data, or place them all on a similar basis, one was converted into terms of the other. The summary of a number of trials in which shelled and ground corn were compared for growing and fattening pigs showed that as determined from the feed required per unit of gain, the average feeding value of ground corn was approximately 4 per cent greater than that of shelled corn. Hence, in computing the relative worth of a substitute and corn, this difference in value, rather than the difference in cost, was used to convert ground corn to a basis of shelled corn.

Although no ear corn was fed in the corn substitute tests, seven comparisons of the two showed that shelled corn was worth 0.7 per cent more, or practically the same a pound, as ear corn on a cob-free basis.

HOMINY FEED

Hominy feed, which is sometimes called hominy meal or hominy chops, is a mixture of corn bran, corn germ (with or without a partial extraction of oil), and a part of the starchy portion of either white or yellow corn kernels, or a mixture thereof, produced in the manufacture of pearl hominy, hominy flakes, corn or hominy grits, or table meal. Whether it is designated white or yellow depends on the color of the corn from which it is made.

Analyses have shown the fiber in hominy feed to range from 2 to 8 per cent and average approximately 4.8 per cent. That in corn averages approximately 2.2 per cent. The nitrogen-free extract, or remainder of the carbohydrates, is lower, and the ash and fat are higher in hominy feed than in corn.

Table 1 summarizes four experiments in dry lot and one on pasture in which white hominy feed and ground yellow corn were compared for growing and fattening pigs. Five pigs to the lot were used in the two earlier dry-lot experiments. In one of these, which lasted 70 days, the corn or hominy feed was full-fed twice daily and the tankage was fed at a given rate per head at each feed. In the other, the corn or hominy feed and the tankage were self-fed separately. The same plan of feeding was followed in one of the two later dry-lot trials except that a supplement composed of tankage, 45, linseed meal, 22.5, ground alfalfa, 22.5, minerals, 10, was used. After 18 weeks, or the time for which the data for the lot were summarized, the pigs receiving the hominy feed slowed up in their rate of growth. Consequently, in the fourth dry-lot comparison, the supplemental feeds were mixed with the corn or hominy feed and a larger amount, or 4 per cent, of ground alfalfa was included in the ration. In the pasture experiment the feeds were mixed and self-fed.

The pigs given hominy feed gained more slowly, required 15 days' more time to reach a given market weight, and consumed a little more total feed but slightly less supplement per unit of gain than similar pigs fed ground yellow corn. With the other feeds at the prices used, the hominy feed was worth 7.2 per cent more a pound than shelled corn. Assuming that the cost of grinding the corn is 10 cents for 100 pounds would make the value of the hominy feed 98.4 per cent that of ground corn.

Comparatively recent trials at other stations have shown a lower value for hominy feed than that obtained in the Ohio tests reported in table 1. In two dry-lot experiments of 60 and 65 days' duration at the Indiana, and one of 80 days' duration at the Nebraska Station, hominy feed produced gains 16.9 per

TABLE 1.—White hominy feed as a substitute for corn for pigs

	Ground yellow corn Supplement	White hominy feed Supplement
Number of comparisons	5	5
Pigs at start	59	58
Initial weight per pig, lb.	57	57
Pigs at close	58	55
Final weight per pig, lb.	197	194
Average daily gain, lb.	**1.35**	**1.20**
Days required to gain 160 lb.	119	134
Daily feed per pig, lb.:		
Corn	4.55	
Hominy feed		4.23
Tankage	.39	.31
Linseed meal	.09	.06
Ground alfalfa	.09	.06
Minerals	.07	.05
Total	5.19	4.71
Feed per 100-lb. gain, lb.:		
Corn	336.60	
Hominy feed		352.22
Tankage	28.39	26.03
Linseed meal	6.72	5.17
Ground alfalfa	6.58	5.20
Minerals	5.40	3.66
Total	**383.69**	**392.28**
Cost of feed per 100-lb. gain	$5.03	$5.10
Replacement value of hominy feed, with shelled corn as 100 per cent		107.2%
Replacement value of hominy feed, with ground corn as 100 per cent		98.4%

cent less rapidly and was worth 91.0 per cent as much as shelled corn. The pigs averaged 99, 130, and 138 pounds in weight when they were placed on feed. The feeds were self-fed separately, and the shotes on hominy feed, in spite of its higher protein content, consumed 60 per cent more tankage per unit of gain than those on corn. That the hominy feed showed a lower value than corn, as determined from the worth of the feeds replaced by it, was partly due to the consumption of the larger amount of tankage.

In six pasture experiments at the Iowa and one at the Nebraska Station, hominy feed produced gains 2.4 per cent less rapidly than corn and was worth 97 per cent as much as shelled corn. The pigs averaged from 41 to 104 pounds in weight at the start and were fed for periods ranging from 60 to 160 days in length.

A summary of all 15 trials, including the Ohio tests and both the dry-lot and pasture experiments at other stations, showed hominy feed to have an average value 98.2 per cent that of shelled corn. Presumably the hominy feed would have shown a trifle higher value if less rather than more tankage had been consumed with the hominy feed than with the corn in two or three of the experiments. Failure to include alfalfa or some other source of vitamin A in four of the seven dry-lot experiments probably also caused the hominy feed to show a slightly lower relative value. The pigs having hominy feed made slower gains and would have required an average of 13 days' more time to make a gain of 160 pounds each. They consumed 0.37 pound less total feed daily a head.

According to four Indiana and eight Ohio trials, conducted before 1914, hominy feed was worth somewhat more than an equal weight of ground corn when both were supplemented with tankage. In 10 of the 12 trials the pigs

averaged over 90 pounds in weight when they were placed on feed. One trial was continued for 120 days. The others were from 40 to 80 days in length. Experiments of short duration and those with well-grown shotes are less exacting than are those with younger pigs that are fed for a longer period of time. Hominy feed formerly contained around 8 per cent of fat. As now manufactured it usually contains around 6 per cent of fat. The amount of fiber contained influences the feeding value of a product for growing and fattening pigs. A hominy feed low in fiber would be expected to be worth more than one higher in fiber. Possibly such factors as these account for the difference in results secured in the early and later experiments with hominy feed.

White and yellow hominy feeds were compared in two Ohio tests, which are reported in table 2. In the first of these the hominy feed and the supplement, which was composed of tankage, 45, linseed meal, 22.5, ground alfalfa, 22.5, minerals, 10, were self-fed separately. The pigs were confined indoors in pens floored with concrete and were on the experimental rations for a period of 19 weeks. Those on the white and those on the yellow hominy feed then averaged 209 and 205 pounds in weight, respectively. Five of the pigs receiving the yellow hominy feed became somewhat crampy after having been on feed for 16 weeks, and two more developed similar symptoms the following week. For the remaining 2 weeks of the test the hominy feed and the supplement were mixed in the ratio of 8:1, and 1 per cent of cod-liver oil was added to the ration. The pigs showed a favorable response to the change. No ill effects from the white hominy feed were observed until the nineteenth week, when the pigs receiving it made an average daily gain of 0.94 pound as compared with one of 1.32 pounds for the preceding 2-week period.

In order to avoid the disturbing influence of the crampy condition of some of the pigs at the close of the test, the results of the trial for a period of 16 weeks rather than for the full length of the test are given. At the end of the 16 weeks the pigs on the yellow and those on the white hominy feed averaged approximately 185 and 180 pounds in weight, respectively. At the end of the nineteenth week, the pigs that had received the yellow hominy feed had required 16 pounds less feed per 100 pounds of gain than those that had received the white hominy feed.

Since the pigs had become crampy in the first trial, all of the feeds were mixed and a larger amount, or 4 per cent, of alfalfa was included in the rations for the second comparison. It was carried on during the summer rather than during the winter months.

Yellow hominy feed produced slightly faster gains and a slightly larger amount of gain per unit of feed in both trials than did white hominy feed. The data obtained indicated that with ground alfalfa included in the rations, yellow hominy feed was worth 1.3 per cent more in one test and 1.8 per cent more in the other than was the white hominy feed. Such differences are too small to be regarded as significant.

Yellow hominy feed contains some vitamin A value unless it is destroyed in the manufacturing process. White hominy feed does not. If a feed that is lacking or low in vitamin A is used, the deficiency may be overcome by feeding it to pigs on pasture or by including 4 per cent or so of ground leguminous hay or an equivalent amount of some material that is rich in vitamin A in the ration. Apparently more ground alfalfa or feed of similar character is needed with hominy feed than with corn.

TABLE 2.—Comparisons of yellow and of white hominy feeds for pigs

	Experiment 1 Hominy feed and supplement self-fed separately		Experiment 2 Hominy feed and supplement mixed and self-fed	
	White hominy feed Supplement	Yellow hominy feed Supplement	White hominy feed Supplement	Yellow hominy feed Supplement
Pigs at start	19	20	9	9
Initial weight per pig, lb.	61	61	48	48
Pigs at close	17	17	8	9
Final weight per pig, lb.	180	185	210	216
Average daily gain, lb.	**1.07**	**1.08**	**1.15**	**1.20**
Days required to gain 160 lb.	150	149	140	134
Daily feed per pig, lb.:				
Hominy feed	3.86	3.84	3.75	3.87
Tankage	.22	.22	.33	.35
Linseed meal	.11	.11	.17	.17
Ground alfalfa	.11	.11	.18	.19
Minerals	.05	.05	.06	.06
Total	4.35	4.33	4.49	4.64
Feed per 100-lb. gain, lb.:				
Hominy feed	359.85	355.60	327.44	322.58
Tankage	20.76	20.61	28.99	28.70
Linseed meal	10.38	10.31	14.50	14.35
Ground alfalfa	10.38	10.31	15.67	15.45
Minerals	4.62	4.58	5.20	5.15
Total	**405.99**	**401.41**	**391.80**	**386.23**
Cost of feed per 100-lb. gain	$5.22	$5.16	$5.13	$5.05
Value of yellow hominy feed with white hominy feed as 100 per cent	.....	101.3%	.....	101.8%

Corn oil is a softening oil. According to Ellis and Isbell,[1] corn oil and soybean oil have iodine numbers of 126 and 128 and refractive indexes at 40° C. of 1.4673 and 1.4648, respectively. Of 111 samples of hominy feed, analyses for which were reported in Bulletins 209, 217, and 242 of the Indiana Experiment Station, 46 contained 8.5 per cent or more and only 17, 7 per cent or less of fat or oil. The fat from the hominy feed in a ration containing 90 per cent of hominy feed analyzing 7 per cent of fat would be 6.3 per cent. To supply as much fat in a corn and soybean ration would require approximately 1 pound of soybeans to every 4 pounds of corn. Since this is more than double the amount of beans that can be fed for a prolonged period of time without danger of producing soft pork, the likelihood of producing soft pork from feeding hominy feed containing as much as 7 per cent of fat is obvious.

Manufacturers could help reduce the softening effect of hominy feed by reducing its oil content. According to the definition adopted in 1935 by the Association of Feed Control Officials, hominy feed "shall contain not less than 5 per cent of crude fat." For producing firm pork, a fat content not in excess of 4 or 4.5 per cent would be preferable.

CORN OIL MEAL

The Association of Feed Control Officials makes a distinction between corn oil meal and corn germ meal. Corn oil meal, according to their definition, consists of the corn germ from which a part of the oil has been pressed, and is the product, after it is ground, obtained in the *wet milling* process of manufacture

[1]Jour. Biol. Chem., July 1926, Vol. LXIX, No. 1, p. 231.

of corn starch, corn sirup, and other corn products. The definition given corn germ meal is that it consists of the corn germ from which part of the oil has been pressed, and is the product, after it is ground, obtained in the *dry milling* process of manufacture of corn meal, corn grits, hominy, and other corn products. The first step in the wet milling process is to soak or steep the corn in warm water containing a small quantity of sulfur dioxide to aid in softening the corn and to prevent its fermenting while soaking.

Corn oil meal usually contains from 7 to 12 per cent of fat and 18 to 24 per cent of protein. Corn germ meal ordinarily analyzes 6 to 9 per cent of fat and 17 to 20 per cent of protein. A sample of the corn oil meal that was fed as a complete and as a partial substitute for corn in the pasture experiment reported in tables 3 and 4 contained 18.8 per cent of protein, 10.2 per cent of fat, and 8.5 per cent of fiber. The corn germ meal fed in the pasture and in one of the dry-lot experiments reported in table 5 analyzed 17.0 per cent of protein, 9.2 per cent of fat, and 6.5 per cent of fiber.

Corn oil meal was tried as a complete substitute for corn in an experiment on rape pasture in which pigs averaging 49 pounds in weight at the start were used. Although the corn oil meal contained 18.8 per cent of protein, it, like the corn, was supplemented with a small amount of tankage. The results are given in table 3.

TABLE 3.—Corn oil meal as a complete substitute for corn for pigs on rape pasture

	Shelled corn Tankage	Corn oil meal Tankage
Pigs at start	7	7
Initial weight per pig, lb.	49.5	48.9
Pigs at close	7	6
Final weight per pig, lb.	146.4	136.5
Average daily gain, lb.	1.15	.70
Days required to gain 160 lb.	140	229
Daily feed per pig, lb.:		
Corn	3.49	.....
Corn oil meal	.....	3.18
Tankage	.25	.10
Total	3.74	3.28
Feed per 100-lb. gain, lb.:		
Corn	302.43	.....
Corn oil meal	.....	455.95
Tankage	21.67	14.35
Total	324.10	470.30
Cost of feed per 100-lb. gain*	$3.89	$6.02
Replacement value of corn oil meal with shelled corn as 100 per cent	.....	69.5%

*Does not include cost of pasture.

The corn oil meal had a marked laxative effect and caused considerable scouring throughout the test. It was not satisfactory for replacing all the corn in the ration. When used in this way, the corn oil meal showed a value only 69.5 per cent as great as that of corn and produced gains only 61 per cent as rapidly.

Corn oil meal was used as a partial substitute for corn in one experiment with shotes approximating 130 pounds in weight at the start and in three with pigs approximating 50 pounds in weight at the start. One of the pig experiments was on pasture. The others were in dry lot. Less tankage or protein

concentrate was fed with corn oil meal than without it, so that the total protein in the rations would be approximately the same. These experiments are reported in table 4.

TABLE 4.—Corn oil meal as a partial substitute for corn for shotes and for growing and fattening pigs, on pasture and in dry lot

	Fattening shotes in dry lot Started Nov. 12, 1919		Growing and fattening pigs on rape pasture Started July 15, 1919		Growing and fattening pigs in dry lot Started July 28, 1937, and July 6, 1938	
	Ground corn Tankage	Ground corn Corn oil meal Tankage	Shelled corn Tankage	Shelled corn Corn oil meal Tankage	Ground corn Tankage Linseed meal Ground alfalfa Minerals	Ground corn Corn oil meal Tankage Linseed meal Ground alfalfa Minerals
Number of comparisons	1	1	1	1	2	2
Per cent in ration	.....	13.6	.....	47.9	.....	21.0
Ratio to corn	.....	1:6	.....	1:1	.....	1:3.1
Pigs at start	4	4	7	7	20	20
Initial weight per pig, lb.	132.6	129.2	49.5	48.1	50.0	50.6
Pigs at close	4	4	7	7	20	20
Final weight per pig, lb.	279.4	281.2	146.4	142.9	199.8	196.6
Average daily gain, lb.	**1.50**	**1.55**	**1.15**	**.97**	**1.04**	**.93**
Days required to gain 160 lb.	107	104	139	166	154	173
Daily feed per pig, lb.:						
Corn	5.94	5.39	3.49	1.75	3.68	2.71
Corn oil meal	.....	.90	.....	1.75	.....	.87
Tankage or meat scraps	.49	.30	.25	.15	.44	.22
Linseed meal	.....	.....	.....	.....	.22	.11
Ground alfalfa	.....	.....	.....	.....	.18	.17
Minerals	.....	.....	.....	.....	.06	.08
Total	6.43	6.59	3.74	3.65	4.58	4.16
Feed per 100-lb. gain, lb.:						
Corn	396.43	347.32	302.43	180.65	352.49	291.74
Corn oil meal	.....	57.88	.....	180.65	.....	94.30
Tankage or meat scraps	33.04	19.30	21.67	15.49	42.36	24.23
Linseed meal	.....	.....	.....	.....	21.18	12.11
Ground alfalfa	.....	.....	.....	.....	17.56	17.96
Minerals	.....	.....	.....	.....	5.32	8.71
Total	**429.47**	**424.50**	**324.10**	**376.79**	**438.91**	**449.05**
Cost of feed per 100-lb. gain	$5.60	$5.41	$3.89	$4.64	$5.77	$5.76
Value of corn oil meal with shelled corn as 100 per cent	.....	135.7%	.....	74.3%	.....	108.6%

The meat scraps which were fed instead of tankage in one of the dry-lot experiments with pigs averaged 22.93 and 14.57 lb. per 100 lb. of gain for the check and the corn oil meal groups, respectively.

When corn oil meal was fed to shotes and used at the rate of 1 pound to 6 of corn, it showed a value approximately a third greater a pound than that of shelled corn. Since the data are for a single trial in which there were only four animals in each group, they are not regarded as conclusive.

The experiment on pasture was the same one in which a different group, reported in table 3, was fed corn oil meal as a complete substitute for corn. Although a better showing was made by the corn oil meal when it replaced half than when it replaced all of the corn, apparently the proportion was too high for the most satisfactory results with pigs of the weight used, even though they were on pasture. The value obtained for the corn oil meal under these conditions was 74 per cent as great as that of shelled corn, and the pigs that received the corn oil meal gained 16 per cent more slowly than those without it.

In the two later experiments with growing and fattening pigs in dry lot, corn oil meal was fed at the rate of 21 per cent of the total feed, or at an average rate of 1.5 pounds for each pound of supplement. The pigs were hand-fed rather than self-fed. Those on the ration containing corn oil meal took less feed daily a head, were ready for market 19 days later, and required 2.3 per cent more feed per unit of gain than those on a similar ration without it. Because of the saving in tankage and linseed meal needed to provide an equivalent amount of protein in the ration, the corn oil meal showed an average value, under these conditions, 8.6 per cent greater a pound than that of shelled corn.

CORN GERM MEAL

No pasture experiments with corn germ meal were conducted except one in which rations of corn, 3, corn germ meal, 1, and of corn, 19, tankage, 1, were compared. When fed in this way, as a complete substitute for tankage and partial substitute for corn, the corn germ meal was worth 91.3 per cent as much a pound as shelled corn. Possibly a little tankage would have improved the ration and caused the corn germ meal to show a higher value.

Corn germ meal was used at the rate of 17.4 per cent of the total feed, or 1 pound to every 4.5 pounds of corn, in one dry-lot experiment. In two others it made up 21 per cent of the total feed, or averaged approximately 1.5 pounds for each pound of supplement. In these two experiments there were also groups, the data for which were given in table 4, which were fed corn oil meal at a corresponding rate. The corn germ meals and likewise the corn oil meals for the tests were obtained from different sources.

Pigs fed the rations containing corn germ meal ate less feed daily a head and were ready for market 11 days later but required 3 per cent less feed per unit of gain than those fed a similar ration without it. The reduced amount of protein concentrate needed and the slight saving in feed per unit of gain caused the corn germ meal to show a feeding value 37.5 per cent greater than that of shelled corn.

Although both consist of the corn germ from which a part of the oil has been pressed, the product obtained by the dry milling process showed a higher value than that obtained by the wet milling process. In the dry-lot trials with pigs started at approximately 50 pounds in weight, the corn germ meal was worth 28.9 per cent more than the corn oil meal. In the two experiments in which they were compared directly, the corn oil meal was worth 8.6 and the corn germ meal, 46.2 per cent more a pound than shelled corn.

In tests at other stations, corn oil meal and corn germ meal fed as complete substitutes for corn to shotes in dry lot were worth 2 per cent and 108 per cent as much a pound, respectively, as shelled corn. When each was fed as a partial substitute for corn to shotes in dry lot, corn oil meal was worth 96 and corn germ meal, 108 per cent as much a pound as shelled corn. Presumably corn oil meal would compare more favorably for feeding as a partial rather than as a complete substitute for corn, for feeding in limited rather than in more liberal amounts, for feeding on pasture rather than in dry lot, and for feeding to shotes rather than to younger pigs. Possibly a technique of manufacture could be worked out which would result in corn oil meal having a relatively higher feeding value.

TABLE 5.—Corn germ meal as a partial substitute for corn, for pigs on pasture and in dry lot

	On rape pasture Started June 17, 1918		In dry lot Started Aug. 22, 1919, July 28, 1937, and July 6, 1938	
	Ground corn Tankage	Ground corn Corn germ meal	Ground corn Tankage Linseed meal Ground alfalfa Minerals	Ground corn Corn germ meal Tankage Linseed meal Ground alfalfa Minerals
Number of comparisons	1	1	3	3
Per cent in ration	.....	25	.....	20.7
Ratio to corn	.....	1:3	.....	1:3.2
Pigs at start	6	6	24	24
Initial weight per pig, lb	59.9	60.0	53.7	53.2
Pigs at close	6	6	24	24
Final weight per pig, lb	204.8	200.7	189.2	188.8
Average daily gain, lb.	**1.38**	**1.26**	**1.05**	**.98**
Days required to gain 160 lb	116	128	153	164
Daily feed per pig, lb.:				
Corn	4.61	3.56	3.72	2.75
Corn germ meal	.....	1.18	.....	.86
Tankage or meat scraps	.24	.....	.44	.22
Linseed meal	.....	.....	.21	.10
Ground alfalfa	.....	.....	.17	.15
Minerals	.....	.....	.05	.07
Total	4.85	4.74	4.59	4.15
Feed per 100-lb. gain, lb.:				
Corn	333.96	282.97	354.54	280.08
Corn germ meal	.....	94.32	.....	87.42
Tankage or meat scraps	17.58	.....	41.51	22.66
Linseed meal	.....	.....	19.53	10.44
Ground alfalfa	.....	.....	16.19	15.30
Minerals	.....	.....	4.91	7.40
Total	**351.54**	**377.29**	**436.68**	**423.30**
Cost of feed per 100-lb. gain	$4.15	$4.36	$5.73	$5.43
Value of corn germ meal with shelled corn as 100 per cent	.....	91.3%	.....	137.5%

The meat scraps which were fed instead of tankage in one dry-lot experiment averaged 21.14 and 12.32 lb. per 100 lb. of gain for the check and the corn germ meal groups, respectively.

BARLEY

Barley is often used as a substitute for corn. In Europe and in Canada it is the grain most commonly fed to hogs. Comparatively large amounts of barley are also used for swine in the northern and western parts of the United States.

Because of the hull it carries, barley has a fiber content approximately 2.5 per cent higher, or is slightly bulkier in character, than corn. Barley usually contains about 1.3 per cent more ash and from 1.5 to 2 per cent more protein than corn. The fat content of corn ranges from 4.5 to 5 per cent. That of barley is around 2.1 per cent.

Table 6 summarizes three experiments in which ground barley was compared with ground corn and two in which it was compared with shelled corn for growing and fattening pigs. One of the experiments in which shelled corn was used was conducted on rape pasture. In it the pigs were full-fed grain twice daily and given an allowance of one-eighth of a pound of tankage per head at

each feed. The others were dry-lot experiments. In one, the pigs were also full-fed twice daily and given tankage which was mixed with the ground grain in the ratio of 1:14. In the others, a supplemental mixture of tankage, linseed meal, ground alfalfa, and minerals was used. In two of these, the supplement and the grain were mixed and fed twice daily. In the third one, shelled corn was used and the supplemental mixture and the grain were self-fed separately.

TABLE 6.—Ground barley as a complete substitute for corn

	Corn Supplement	Barley Supplement
Number of comparisons	5	5
Pigs at start	43	45
Initial weight per pig, lb.	55.4	55.8
Pigs at close	42	45
Final weight per pig, lb.	201.8	204.4
Average daily gain, lb.	1.16	1.12
Days required to gain 160 lb.	139	143
Daily feed per pig, lb.:		
Corn	3.86	.....
Barley	.....	4.09
Tankage	.35	.22
Linseed meal	.13	.08
Ground alfalfa	.10	.09
Minerals	.04	.04
Total	4.48	4.52
Feed per 100-lb. gain, lb.:		
Corn	333.40*	.....
Barley	.....	366.26
Tankage	29.71	20.22
Linseed meal	11.13	6.92
Ground alfalfa	8.90	7.76
Minerals	3.67	3.36
Total	**386.81**	**404.52**
Cost of feed per 100-lb. gain	$4.94	$5.18
Replacement value of ground barley with shelled corn as 100 per cent.	.....	100.3%

*40.58 per cent, or 135.31 lb. per 100 lb. of gain, of corn was shelled. The remainder was ground.

Summary includes one experiment with five pigs to the lot on rape pasture. The others were dry-lot experiments.

The pigs fed barley required 4 days' more time to make an average gain of 160 pounds than those fed corn. As determined from the feed required per unit of gain, the ground barley had an average value 0.3 per cent greater than, or approximately the same as, an equal weight of shelled corn.

Barley showed a higher value in these tests than in some experiments at other stations. In 19 dry-lot experiments, including the 5 conducted at the Ohio Station, with pigs carried from an average of 61 pounds to one of approximately 215 pounds in weight, the average worth of ground barley was 92.6 per cent that of shelled corn. Those fed corn were ready for market 8 days earlier than those fed barley.

In 13 comparisons on pasture with pigs averaging 55 pounds in weight at the start and approximately 200 pounds at the close, ground barley had an average value 86.4 per cent that of shelled corn. The corn-fed pigs made an average gain of 160 pounds each in 13 days' less time than the barley-fed pigs.

In 18 dry-lot experiments with shotes having an average initial weight of 123 pounds, the average worth of ground barley was 87.2 per cent that of shelled corn. The corn produced gains 6.4 per cent more rapidly than the barley.

A larger amount of feed was taken daily a head by the barley-fed pigs, both in the experiments with shotes and in those with growing and fattening pigs, regardless of whether they were in dry lot or on pasture. Barley is not regarded as being more palatable than corn. That more ground barley than shelled corn was rooted out of the feeders and wasted in the experiments in which the two were compared for self-feeding has been offered as a possible explanation of the apparently larger amount of feed consumed by the barley- than by the corn-fed pigs. Another possible explanation suggested by the same investigator but thought by him to be of less importance was that the shelled corn may have been more thoroughly masticated than the ground barley.

Whether ground barley was compared with shelled or with ground corn probably influenced to some extent the relative amounts of feed consumed. In 8 out of 11 experiments comparing ground and shelled corn for growing and fattening pigs that were full-fed, the pigs fed ground corn consumed more feed than those fed shelled corn. An average of 3.2 per cent more feed daily a head was consumed. In the comparisons of ground barley and corn, shelled corn was used in 15 of the 19 dry-lot trials with growing and fattening pigs, in all of the 13 trials with similar pigs on pasture, and in 15 out of 18 trials with heavier shotes. The pigs or shotes that were fed ground barley ate 3.0, 4.5, and 6.1 per cent more feed daily a head, respectively, than those fed corn.

The difference in fiber could possibly have had some effect on the relative amounts of feed consumed.

Hull-less barley contains less woody or fibrous material than the hull varieties. No trials with it were conducted at the Ohio Station. In four tests at the Montana and one at the Wyoming Experiment Station with pigs carried from approximately 82 to 195 pounds in average weight, those fed hull-less barley ate 3 per cent more feed daily, reached the final weight 9 days earlier, and required 7.8 per cent less feed per 100 pounds of gain than those fed hull barley. Considering only the difference in feed per 100 pounds of gain, the hull-less barley was worth 9.3 per cent more than the hull barley. The feeding value of hull-less barley, after it is rolled or ground, is thus about equal, or perhaps slightly superior, to that of an equal weight of shelled corn.

The theory that the larger amount of fiber in rations containing barley than in those containing corn possibly has a tendency to bring about an increase in feed consumption was not supported by the experiments with hull-less barley.

No experiments were conducted at the Ohio Experiment Station in which whole and ground barley were compared, but a summary of 16 tests at other stations shows that when only the difference in feed required per unit of gain was taken into account, ground barley was worth approximately 16.3 per cent more than whole barley. At the prices used, this was equivalent to 8.8 cents a bushel. The pigs that were fed ground barley took 8.7 per cent more feed daily a head and were ready for market 28 days earlier on the average than were those fed the whole barley.

If the barley and supplement are self-fed separately, pigs may not take them in the proportions that will produce optimum results so far as rapidity of gains, gains per unit of feed, and financial returns are concerned. In an experiment on rape pasture with pigs carried from 72 to 215 pounds in average weight, self-feeding a mixture of ground barley, 14, tankage, 1, was compared with self-feeding the two feeds separately. The pigs having access to the two feeds separately took 1 pound of tankage to each 9 pounds of barley. Although

they ate slightly more total feed daily per unit of live weight they gained more slowly and required 11.5 per cent more feed per unit of gain than those having access to the mixture.

A Nebraska report states that the use of an unpalatable barley apparently caused the pigs to fill up on supplementary feeds. In an Iowa experiment the supplement and barley were taken in almost a 1:1 ratio. In a trial at the Minnesota Station, on the other hand, too little rather than too much supplement was taken when it and barley were self-fed separately. That mixing the barley and supplement in suitable proportions was preferable to self-feeding them separately was also shown by tests at the Oklahoma, South Dakota, and Wisconsin Stations. Approximately 1 pound of the trio mixture or of a supplemental feed containing around 40 per cent of protein, to 7 pounds of barley for pigs in dry lot between 60 and 120, and 1 to 10 pounds for pigs over 120 pounds in weight is needed.

Mixing ground oats, middlings, or similar feeds with ground barley is recommended by some investigators.

Barley is sometimes infected with scab, or fusarium blight. The diseased areas of the infected kernels are pinkish in color. Scabby barley is more prevalent some seasons than others. An unusually large percentage of the 1928 crop was affected. Findings at the Experiment Station agreed with those reported by farmers. Pigs usually refused to eat the barley if it contained many scabby grains. If they were forced to consume infected grain, it not uncommonly caused vomiting within a relatively short time.

Roche and Bohstedt of the Wisconsin Experiment Station carried on some investigations with barley, 80 per cent of the kernels of which were infected with scab. In their tests pigs fed rations containing 12.5 per cent of the scabby barley made practically normal growth. Other pigs fed rations containing 30 per cent or more of scabby barley lost in weight. Washing the infected barley in water or in dilute acid or alkali solutions or feeding it with milk was not effective in overcoming its toxicity. When the barley which floated was skimmed off, a larger percentage of the infected grains was removed. Pigs fed the remainder gained rather than lost in weight but did not make normal growth.

Cattle, sheep, and poultry were unaffected, apparently, by the feeding of scabby barley. Scabbed oats containing 70 per cent of infection were not palatable to horses when they made up 60 per cent or more of their grain ration. In view of these results and the fact that an injected dog responded in a similar manner, the conclusion was reached that animals with simple stomachs react to the toxic substance but that those with complex stomachs do not.

Wheat is considered equally as susceptible and rye and oats, somewhat less susceptible to scab than barley. Possibly, because of milder infections or because they are less likely to make up as large a share of the grain portion of the ration, no ill effects from scab when these grains have been fed have come to the writer's attention.

OATS

Among the grain crops of the State, oats production is exceeded only by that of corn and wheat. Oats, however, are not so well adapted for extensive use in the feeding of swine as are the other grains. Because of their hulls, they are too bulky or fibrous in character to produce maximum gains when

they are used as the only grain for pigs. Although the proportion varies widely, oats contain an average of approximately 30 per cent of hull by weight, or 9.6 pounds of hulls and 22.4 pounds of kernels to the bushel.

Eight comparisons of corn and oats for pigs in dry lot, with each used as the only grain in the ration, are summarized in table 7. The pigs were full-fed twice daily in three of the experiments and self-fed in the others. Except in one trial, in which shelled corn was used and in which the supplement and the grain were self-fed separately, both the oats and corn were ground and mixed with the supplement. The supplement consisted of tankage alone in one trial, of the trio mixture and minerals in four, and of the same feeds with the exception of the linseed meal in three tests. Since oats contain around 12.4 and corn around 9.4 per cent of protein, when the feeds were mixed less tankage or tankage and linseed meal were fed with the oats than with the corn, so that the percentages of total protein in the rations were approximately the same.

TABLE 7.—Oats as a complete substitute for corn for growing and fattening pigs

	Corn Supplement	Oats Supplement
Number of comparisons	8	8
Pigs at start	74	75
Initial weight per pig, lb	54	53
Pigs at close	70	73
Final weight per pig, lb	202	199
Average daily gain, lb	**1.10**	**.96**
Days required to gain 160 lb	146	167
Daily feed per pig, lb.:		
Corn	3.73	
Oats		4.35
Tankage	.39	.18
Linseed meal	.12	.05
Ground alfalfa	.12	.12
Minerals	.06	.06
Total	4.42	4.76
Feed per 100-lb. gain, lb.:		
Corn	338.71*	
Oats		453.10
Tankage	34.99	18.65
Linseed meal	10.86	5.23
Ground alfalfa	11.06	12.83
Minerals	5.63	6.01
Total	**401.25**	**495.82**
Cost of feed per 100-lb. gain	$5.26	$6.37
Replacement value of ground oats with shelled corn as 100 per cent		78.7%

*15.28 per cent, or 51.74 lb. per 100 lb. of gain, of corn was shelled. The remainder was ground.

The oats were palatable. In spite of their greater bulk, the pigs receiving them ate more pounds of feed daily a head than those receiving corn. Although it necessitated ingesting a larger amount of fibrous or woody material, apparently the pigs made an effort to obtain as much nutritious material as they would ordinarily consume if given a less fibrous ration. Notwithstanding their higher feed consumption, according to their relative rate of growth, they would have required 3 weeks' more time than the corn-fed pigs to reach a market weight of 215 pounds.

Assuming that the oats contained an average of 30 per cent of hull, 317 pounds of hull-free oats as compared with 339 pounds of corn were required for each 100 pounds of gain produced. The smaller feed requirement per unit of

gain when the oats are reduced to a hull-free basis is thought to be due to factors other than the hulls' having any nutritive value. In an experiment in which pigs fed hulled oats and tankage gained 1.25 pounds daily and required 307 pounds of feed per 100 pounds of gain, pigs given a similar ration containing 22 per cent of oat hulls gained 1.03 pounds daily a head and required 323 pounds of hulled oats and tankage and 92 pounds of oat hulls, or a total of 415 pounds of feed, for each 100 pounds of gain produced.

The higher energy value resulting from the larger percentage of fat contained would account for at least a part of the greater worth of the oats after deducting the weight of the hulls. Oats may possibly also have a beneficial effect in preventing or combating necrotic enteritis, particularly among pigs kept in close confinement, as they were in these experiments. Veterinarians sometimes recommend medicated oats for pigs suffering from enteritis.

At the prices used, and taking into account only the feed required per unit of gain, ground oats, when fed as the only grain, were worth 78.7 per cent as much as shelled corn.

The average fat content of oat kernels, the chief portion of the oat grain utilized by pigs, is approximately 6.4 per cent. This is one and two-thirds times that of corn. Barley, wheat, and rye contain only about half as much fat or oil as corn.

The refractive indexes and iodine numbers of back fat samples from groups of 10 Duroc Jersey and 10 Yorkshire hogs that had been fed corn, barley, and oats, respectively, as the grain portion of their rations, were determined by the Bureau of Animal Industry of the United States Department of Agriculture. Both the iodine numbers and refractive indexes showed that when they were fed as the only grain, oats did not produce as firm fat but that barley produced a firmer pork fat than corn. The iodine numbers indicated that the refractive index values averaged 0.0006 too high. With this correction made, the average refractive indexes of the samples of fat from pigs fed corn, barley, and oats were 1.45951, 1.45916, and 1.46011, respectively.

The average shrunk weight at slaughter of the 20 corn-fed hogs was 203.1 pounds, or 10.5 pounds heavier than that of the 20 oats-fed hogs, which was 192.6 pounds. Fat samples, however, from 10 corn-fed hogs weighing 221 pounds and 10 weighing 185 pounds at slaughter were firmer and had average refractive indexes 0.00085 and 0.00046 lower, as named, than those from five 224-pound and eight 192-pound oats-fed hogs.

Although they made slightly faster gains and were a little heavier when slaughtered, six Duroc-Jersey hogs fed hulled oats as the grain portion of their ration produced a softer back fat, as indicated by a 5.2 higher iodine number and an 0.000327 higher average refractive index, than the hogs of similar breeding fed corn.

Oats have a higher value as a partial than as a complete substitute for corn. Table 8 summarizes six dry-lot and three pasture experiments in which adding some oats to a ration of corn and supplement was tried.

In the dry-lot experiments the pigs fed oats ate a little more feed and made slightly faster gains than those fed merely corn and supplement. More total feed but less tankage and linseed meal were required per unit of gain when ground oats were included in the ration. When fed in this way, with corn, to pigs in dry lot, the ground oats were worth 89.4 per cent as much as shelled corn.

TABLE 8.—Oats as a partial substitute for corn

	In dry lot		On pasture	
	Corn Supplement	Corn Ground oats Supplement	Corn Supplement	Corn Ground oats Supplement
Number of comparisons	6	6	3	3
Pigs at start	62	61	29	28
Initial weight per pig, lb.	58	58	61	61
Pigs at close	58	60	29	28
Final weight per pig, lb.	204	204	208	203
Average daily gain, lb.	1.11	1.14	1.38	1.31
Days required to gain 160 lb.	145	141	116	123
Daily feed per pig, lb.:				
Corn	3.82	3.13	4.74	4.09
Ground oats	.....	1.08	.....	1.06
Tankage	.42	.39	.41	.24
Linseed meal	.14	.12	.....	.....
Ground alfalfa	.14	.15	.....	.....
Minerals	.07	.07	.04	.04
Total	4.59	4.94	5.19	5.43
Feed per 100-lb. gain, lb.:				
Corn	345.16	274.72	344.20	313.42
Ground oats	.....	94.96	.....	81.04
Tankage	38.34	33.79	29.68	18.20
Linseed meal	12.21	10.33	.....	.....
Ground alfalfa	12.44	12.99	.....	.....
Minerals	6.62	6.34	3.09	3.08
Total	414.77	433.13	376.97	415.74
Cost of feed per 100-lb. gain	$5.52	$5.71	$4.83	$5.21
Value of ground oats with shelled corn as 100 per cent.	.....	89.4%	.....	67.7%

In the dry-lot comparisons, all the corn was ground. Linseed meal was included in the supplement in three of the six comparisons.

In the pasture experiments, 33.31 per cent, or 114.67 lb. per 100 lb. of gain, of the corn, when it was fed as the only grain, was shelled and the remainder ground. When fed with oats, 35.88 per cent, or 112.45 lb. per 100 lb. of gain, of the corn was shelled and the remainder ground.

Rape pasture was used in two experiments and red clover in one experiment.

An average of approximately 1.5 pounds of oats to each pound of the supplemental mixture was used. If ear corn is fed, as is usually advisable, feeding a given quantity of oats daily a head or apportioning the oats in relation to the supplement is simpler than apportioning them in relation to the corn. The amount of oats fed averaged approximately 1 pound to every 3 pounds of corn.

Carroll reported that oats fed with supplement and corn did not slow down the rate of gain unless they made up almost half the ration but that oats did reduce the efficiency of the ration even when they made up as little as one-fourth of the grain. He concluded that to be fed profitably, oats must be as cheap a pound as corn and that unless they are very much cheaper than corn, they should not constitute more than about one-third of the grain ration for fattening pigs.

In the experiments reported in table 8 oats were worth less for feeding with corn to pigs on pasture than to pigs in dry lot. Apparently oats supply nothing beneficial that is not otherwise supplied in a ration of corn, a protein concentrate, minerals, and pasture. Perhaps the less favorable showing of oats under pasture than under dry-lot conditions was due chiefly to the rather fibrous or bulky character of both the pasture and oats. In the pasture trials, approximately 1 pound of oats to every 4 pounds of corn or 4 pounds of oats to every pound of tankage were consumed. The oats decreased rather than increased the rate of growth. Fed under pasture conditions, the ground oats were worth 67.7 per cent as much a pound as shelled corn.

In three experiments with pigs started at an average initial weight of 59 pounds, ground oats were worth 27 per cent more than whole oats when they were fed at the rate of approximately 1 pound to every 3 pounds of corn, and 21 per cent more than whole oats when they were fed as the only grain in the ration. With other feeds at the prices used and whole oats at 36 cents a bushel, the advantage from grinding amounted to 9.7 and 7.6 cents a bushel, respectively.

For shotes averaging approximately 100 pounds when placed on feed, ground oats were worth 33 per cent more than whole oats when they were fed along with corn at an average rate of 1 pound of oats to every 3.23 pounds of corn, and 22 per cent more when they were fed as the only grain. The data are from two comparisons with eight shotes to the lot in each experiment.

Except in 2 comparisons out of 10, one when the oats were fed as the only grain to growing and fattening pigs and one when they were fed with corn to shotes, grinding oats was preferable to feeding them whole.

In tests at the Iowa Station, soaking either whole or ground oats and feeding them twice daily, as compared with self-feeding dry oats, did not increase the gains from a given quantity of feed.

HULLED OATS

Oats with the hulls removed are especially palatable to pigs. They contain even less fiber and are higher in protein, fat, and total digestible nutrients than corn. In the past, although their excellent qualities were recognized, the cost of hulled oats prohibited their use except to a very limited extent in the development of valuable show or breeding stock. The manufacture of oat hullers for general use has broadened the interest in hulled oats for pigs.

In an experiment with hulled oats, supplemented with tankage, that was conducted during the winter of 1920 and 1921, exceptionally rapid gains and larger gains per unit of feed were produced for a time, but after about 12 weeks the pigs began to get stiff, crampy, or lame. Consequently, in 1927, when hulled oats were tried again, they were fed to two groups of pigs. One was fed minerals along with the hulled oats and tankage. The other was fed both alfalfa and minerals. There were eight pigs in each group. One pig in the group getting no alfalfa died during the early part of the test from an unknown cause. Six of the seven remaining pigs became stiff or crampy before the close of the test. The symptoms appeared in from 10 to 14 weeks after the beginning of the experiment. During the first 8 weeks the lot gained 1.10 pounds daily a head as compared with an average gain of 1.14 pounds for those receiving alfalfa. By the end of the sixteenth week the pigs receiving alfalfa had outgained those without it an average of 0.42 pound daily a head. A ration of hulled oats, tankage, and minerals was definitely deficient in antirachitic properties, but the deficiency was largely if not completely corrected by the addition of alfalfa.

In the 1920 experiment, a group of pigs fed ground whole oats and tankage and another group fed yellow corn and tankage were continued on feed until they averaged approximately 230 pounds in weight, without showing any symptoms of crampiness.

Table 9 summarizes seven experiments in which hulled oats were compared with corn for growing and fattening pigs in dry lot. The supplement consisted of tankage alone in one trial. The data included for this trial are

only for the period previous to the time the pigs fed hulled oats showed any indications of rickets. In two of the comparisons a supplement composed of tankage, ground alfalfa, and minerals was used, and in the remaining four, one composed of the same feeds plus linseed meal. Since hulled oats are higher in protein than corn, less tankage and linseed meal were included in the rations containing hulled oats.

TABLE 9.—Hulled oats as a substitute for corn

	As a complete substitute		As a partial substitute	
	Corn Supplement	Ground hulled oats Supplement	Ground corn Supplement	Ground corn Ground hulled oats Supplement
Number of comparisons	7	7	4	4
Pigs at start	50	50	39	38
Initial weight per pig, lb.	51.4	50.9	58.3	58.7
Pigs at close	44*	40*	37	37
Final weight per pig, lb.	195.6	202.0	200.2	201.3
Average daily gain, lb.	**1.06**	**1.19**	**1.07**	**1.15**
Days required to gain 160 lb.	151	135	150	140
Daily feed per pig, lb.:				
Corn	3.67		3.68	3.04
Hulled oats		3.57		.85
Tankage	.36	.16	.40	.36
Linseed meal	.11	.05	.12	.09
Ground alfalfa	.13	.11	.13	.14
Minerals	.06	.06	.06	.07
Total	4.33	3.95	4.39	4.55
Feed per 100-lb. gain, lb.:				
Corn	345.43		343.09	264.88
Hulled oats		300.70		73.65
Tankage	33.84	13.50	37.37	31.16
Linseed meal	9.94	3.73	11.16	8.16
Ground alfalfa	12.23	9.50	12.29	11.87
Minerals	5.55	4.97	5.85	5.88
Total	**406.99**	**332.40**	**409.76**	**395.60**
Cost of feed per 100-lb. gain	$5.28	$6.59	$5.44	$5.80
Value of hulled oats with shelled corn as 100 per cent.		135.8%		137.2%

*Three of the heavier pigs in the corn lot and four in the hulled oats lot, in one experiment, were removed for slaughter at weights of approximately 200 lb. The others were continued until they reached similar weights.

Linseed meal was included in the supplement in four of the seven experiments with hulled oats as a complete substitute, and two of the four with hulled oats as a partial substitute for corn.

In the complete substitute experiments, 22.59 per cent, or 78.03 lb. per 100 lb. of gain, of the corn was shelled and the remainder ground. In the same tests, 41.08 per cent, or 123.52 lb. per 100 lb. of gain, of the hulled oats was fed whole and the remainder ground.

In the partial substitute experiments, all the corn and all the hulled oats were ground.

The pigs fed hulled oats were ready for market 16 days earlier, on the average, than those fed corn. They required 18 per cent less feed per unit of gain. At the prices used for other feeds, and as determined from the feed required per unit of gain, ground hulled oats, when they were used to replace all of the corn in the ration, were worth 36 per cent more a pound than shelled corn.

Oat hullers differing in price and capacity and designed for farm or commercial hulling have been developed and placed on the market. These vary in efficiency, depending on the machine and the quality, dryness, and variety of oats. From 59.5 to 66.5 per cent of the original weight of the oats is recovered

after hulling. Assuming that 95 per cent of the kernels are hulled, 32 pounds of oats would yield 21.28 pounds of kernels, 9.12 pounds of hulls, and 1.6 pounds of lightweight or other unhulled oats mixed with the hulls. With oats at 36 cents a bushel, hulling at 20 cents a hundred pounds, and with no allowance made for the hulls and unhulled oats, the hulled oats would cost $1.99 a hundred pounds, or 77 per cent more than the price of an equal weight of corn. If an allowance of 0.2 cent a pound were made for the hulls and an allowance of three-fourths the price of the original oats for the lightweight unhulled oats, the cost of the hulled oats would be reduced to $1.84 a hundred pounds, or to 64 per cent more than the price of corn. If 85 instead of 95 per cent of the kernels were hulled, the hulled oats would cost 98 per cent more than corn when no allowance was made for the hulls and unhulled oats, and 71 per cent more when these were valued at the prices given.

Slaughter data were obtained in one of the experiments. In it hulled oats produced no stronger bones nor greater muscular development than corn. Each ration contained approximately equivalent amounts of protein and ash. The pigs in each group averaged 216 pounds in weight when they were butchered. The total bony, fat, and lean cuts from the pigs fed hulled oats averaged 7.2, 40.9, and 51.9 per cent, respectively, of the carcass yield. Those from the corn-fed pigs in the same order averaged 7.2, 41.0, and 51.8 per cent of the carcass yield. The average weight of any of the corresponding cuts differed less than 1 per cent. A femur from each of the pigs fed hulled oats averaged 694, and one from each of those fed corn, 793 pounds in breaking strength.

Feeding limited quantities of hulled oats, or using them to replace only a part rather than all of the corn in the ration was tried in four experiments in which both the corn and the hulled oats were ground. An average of approximately 1.3 pounds of hulled oats for each pound of supplement, or of 1 pound for every 3.6 pounds of corn, was fed. The supplement consisted of tankage, ground alfalfa, and minerals, with linseed meal included in two and omitted in two of the tests.

Ground hulled oats increased the rapidity of the gains in each of the four comparisons. The pigs that received the hulled oats were ready for market 10 days earlier, on the average, than those without them. Considering only the feed required per unit of gain, the ground hulled oats showed an average value, when used to replace approximately one-fifth of the corn, 37.2 per cent greater than that of shelled corn. Other data, unlike the Ohio data, indicated hulled oats to have an appreciably higher value as a partial than as a complete substitute for corn.

HULL-LESS OATS

Hull-less oats are similar in composition and feeding value to hulled oats. At the Ohio Station the 1925-1934 10-year average yield of hull-less oats was 93.4 per cent that of the Miami variety of hulled oats on a hull-free basis. The hull-less oats as threshed contained about 5 per cent of hulls and trash, which was not deducted. Objectionable features of the hull-less oats were that they were weak strawed and subject to smut.

Bulletin 339 of the Illinois Station reports that a hull-less oat ranked fourteenth in average yield among 44 varieties grown at Urbana. To enable them to be stored without spoiling it was necessary for the hull-less oats to be drier than the hulled varieties when they were threshed. The hull-less oats also shattered somewhat worse than the hulled varieties.

Unless susceptibility to smut and a weak straw are characteristics that are linked with absence of hulls (after threshing) in their inheritance, it should be possible to develop a variety that would not be handicapped by these disadvantages and one equal to the better hulled varieties in yield. If oat groats are wanted for pigs, and, at least for use under certain conditions, they are sufficiently high in feeding value to warrant consideration, growing hull-less oats would save the expense of the hulling which would be necessary with ordinary varieties.

OAT HULLS

Oat middlings, oat shorts, and oat hulls are obtained as by-products in the manufacture of rolled oats. Oat middlings are the floury portion of the oat groats or kernels removed in the manufacturing process. Oat shorts are the fuzzy covering of the oat grain lying immediately inside the hull and carrying a considerable portion of the fine floury part of the groat. If the middlings, shorts, and hulls are combined in a single by-product, it is designated as oat feed or oat mill feed.

Oat hulls contain approximately 29 per cent of fiber. Their fibrous or woody character is somewhat similar to that of oat straw. Table 10 gives the results of a dry-lot test in which oat hulls were added to a hulled oats and tankage ration at 10.3 and 22 per cent levels.

TABLE 10.—Effect of adding oat hulls to a hulled oats and tankage ration

	1	2	3
	Hulled oats 72 Tankage 6	Hulled oats 72 Tankage 6 Oat hulls 9	Hulled oats 72 Tankage 6 Oat hulls 22
Approximate fiber in ration, per cent	1.6	4.3	7.4
Number of pigs	5	5	4
Initial weight per pig, lb.	47.7	47.3	46.7
Final weight per pig, lb.	169.1	168.1	166.2
Average daily gain, lb.	**1.24**	**1.05**	**1.00**
Days required to gain 125 pounds	101	119	125
Daily feed per pig, lb.:			
Hulled oats	3.58	3.10	3.09
Oat hulls	.....	.38	.94
Tankage	.30	.26	.26
Total	3.88	3.74	4.29
Feed per 100-lb. gain, lb.:			
Hulled oats	288.94	295.62	307.43
Oat hulls	.....	36.95	93.94
Tankage	24.08	24.63	25.62
Total	**313.02**	**357.20**	**426.99**
Fiber-free feed per 100-lb. gain	308	342	395
Cost of feed per 100-lb. gain	$6.47	$6.89	$7.58

Each increase in the percentage of oat hulls in the ration reduced the rapidity of the gains and increased the other feed required per unit of gain. The presence of a fibrous material reduces the amount of concentrate feeds or of more nutritious material that can be consumed and would thus account for a slowing down in the rapidity of the gains. Since carrying pigs for a longer time in order for them to reach a given weight would increase the feed needed for maintenance, the requirement of a larger amount of concentrate feeds per unit of gain, if a material having little or no nutritive value were added to a ration fed healthy pigs, would not be unexpected.

OAT MIDDLINGS

Including 8 per cent of oat middlings in a ration of corn, tankage, linseed meal, ground alfalfa, and minerals was tried in two experiments, and 8 per cent of oat hulls in one experiment. The results are reported in table 11. According to the analysis submitted, the oat middlings contained 14.5 per cent of protein and not over 3.7 per cent of fiber.

TABLE 11.—Oat products for pigs in dry lot

	Experiment 1 Started Jan. 5, 1932		Experiment 2* Started Dec. 20, 1933		
	Corn	Corn Oat middlings	Corn	Corn Oat middlings	Corn Oat hulls
	Protein mixture,† ground alfalfa, minerals				
Number of pigs	15	15	9	10	10
Initial weight per pig, lb.	57.8	58.0	59.1	59.1	59.3
Final weight per pig, lb.	221.5	229.2	209.9	205.1	204.5
Average daily gain, lb.	**1.22**	**1.29**	**1.33**	**1.37**	**1.22**
Days required to gain 160 lb.	132	124	121	117	133
Daily feed per pig, lb.:					
Ground corn	4.09	3.86	4.04	3.86	3.77
Oat middlings	.....	.42	.....	.40	.....
Oat hulls	.....	.....	.....	.....	.41
Protein mixture	.69	.64	.53	.50	.60
Ground alfalfa	.15	.16	.17	.18	.20
Minerals	.10	.10	.10	.10	.08
Total	5.03	5.18	4.84	5.04	5.06
Feed per 100-lb. gain, lb.:					
Ground corn	334.25	299.98	303.45	281.23	309.09
Oat middlings	.....	32.17	.....	29.36	.....
Oat hulls	.....	.....	.....	.....	33.17
Protein mixture	56.15	49.85	39.90	36.29	48.91
Ground alfalfa	12.33	12.06	12.69	12.74	16.58
Minerals	8.22	8.04	7.27	7.34	6.85
Total	**410.95**	**402.10**	**363.31**	**366.96**	**414.60**
Cost of feed per 100-lb. gain	$5.49	$5.52	$4.77	$4.96	$5.30
Value of oat middlings with shelled corn as 100 per cent	.....	147.3%	.....	100.0%	.....

*In Experiment 2, a 120.5-lb. pig was taken out of the corn lot February 14, and an 81.5-lb. one out of the corn and oat middlings lot January 17.

†Protein mixture: tankage, 2, linseed meal, 1. Steam-rendered tankage was used in the first, and dry-rendered tankage in the second, experiment.

Minerals: Experiment 1, salt, 19.37; limestone, 38.8; special steamed bone meal, 38.8; iron oxide, 2.8; anhydrous copper sulfate, 0.2; potassium iodide, 0.03. Experiment 2, salt, 19; limestone, 38; special steamed bone meal, 38; iron sulfate, 4.97; potassium iodide, 0.03.

The pigs having the oat middlings made slightly faster gains in both trials and greater gains per unit of feed in one trial than those without them. The two rations were practically equal in efficiency in the second trial. At the prices used, the other feeds replaced, per unit of gain, gave the oat middlings a value 47.3 per cent greater than that of shelled corn in the first trial and the same as that of shelled corn in the second. As in the experiment reported in table 10, oat hulls slowed down the rapidity of the gains and increased the amount of other feed required per unit of gain.

RYE

Ground rye was compared with ground corn for pigs in two experiments which are summarized in table 12. In one experiment the carbonaceous feed and tankage were mixed in the ratio of 9:1. The mixture was full-fed twice daily. In the other, the corn, or the rye, and the tankage were self-fed separately. The pigs in the first trial were on one-quarter-acre bluegrass plots, but since the feeding period extended from September 8 to December 8, an ample supply of green feed was available for only a part of the time. In the second trial, which was conducted during the winter, the pigs were kept outside and sheltered in movable houses.

TABLE 12.—Rye as a complete substitute for corn

	Ground corn Tankage	Ground rye Tankage
Number of comparisons	2	2
Pigs at start	10	10
Initial weight per pig, lb	84	83
Pigs at close	10	10
Final weight per pig, lb	218	207
Average daily gain, lb	**1.46**	**1.26**
Days required to gain 160 lb	110	127
Daily feed per pig, lb.:		
Corn	5.41	.....
Rye	.....	5.25
Tankage	.63	.58
Total	6.04	5.83
Feed per 100-lb. gain, lb.:		
Corn	369.39	.....
Rye	.....	415.01
Tankage	43.26	46.05
Total	**412.65**	**461.06**
Cost of feed per 100-lb. gain	$5.50	$6.27
Value of ground rye with shelled corn as 100 per cent	.....	93.9%

Although the rye was of good quality, the pigs fed rye ate an average of 0.2 pound less feed daily a head than those fed corn. The faster gains made by the corn-fed pigs would have enabled them to be marketed 17 days earlier than the pigs fed rye. Considering only the feed replaced by it per unit of gain, the ground rye was worth 93.9 per cent as much a pound as shelled corn.

Inasmuch as rye is not particularly palatable to pigs, perhaps the inclusion of some corn, oats, or middlings in the ration when rye is fed would increase the tastefulness and the efficiency of the ration.

Rye should be ground rather than fed whole. At the Delaware Station whole and ground rye, supplemented with tankage, were compared for self-feeding. The ground rye produced 19 per cent faster gains and saved sufficient rye and supplement per unit of gain to give it a value 17.9 per cent greater than that of the whole rye. At the prices used, this was equivalent to 11.6 cents a bushel in favor of grinding the rye over feeding it whole.

Rye, like other grains, with the exception of yellow corn, is probably deficient in vitamin A. If it is fed to pigs that are not on pasture, including approximately 4 per cent of ground alfalfa or a smaller amount of some material carrying a greater concentration of vitamin A in the ration would be expected to prove beneficial.

The nutritive properties of rye were studied by Johnson and Palmer at the Minnesota Station. They concluded that a deficiency of either vitamin B or G in rye was unlikely when rye was fed at the levels used for livestock, that lysine but not tryptophane is the first limiting amino acid of the proteins of rye, and that any unsatisfactory results from rye were not attributable to a toxic principle in the germ.

Rye is often contaminated with ergot. Sackville and Sinclair found that rye containing 1.46 per cent of ergot was worth 8 per cent less for pigs than rye that was free of ergot. The pigs did not eat enough of the ergot-infected rye to make satisfactory gains. Johnson and Palmer replaced 1 per cent of rye in a pig ration with ergot. The ergot cut down feed consumption and retarded growth to a statistically significant degree. Pigs that were limited to an equal amount of ergot-free feed made 39 per cent greater gains than those given a ration containing 1 per cent of ergot. The content of the principles causing the distastefulness of ergot apparently varied considerably. After 1 year in storage, ergot had not lost its distastefulness for swine. The conclusion was reached that because it was distasteful, there was little danger that rye containing ergot would produce gross symptoms of ergotism in swine. Since ergot may cause abortion, caution to see that rye to be fed to pregnant sows is free from ergot is necessary.

WHEAT

Wheat is usually worth more for milling purposes than for feeding. Once in a great while, however, its price in relation to that of corn drops so low that it becomes an economical feed for swine. Table 13 gives the results of four dry-lot experiments in which wheat and corn were compared for growing and fattening pigs. Ground corn was fed in two and shelled corn in two of the tests. The wheat was ground in each of the four comparisons. Except in one trial, in which only tankage was used, the supplement consisted of a mixture of tankage, linseed meal, ground alfalfa, and minerals. In this trial the tankage was fed at the rate of 0.4 pound daily a head. In the other tests the supplemental mixture and the corn or the wheat were self-fed separately.

The pigs fed wheat took a little less feed daily a head but reached a similar market weight only 5 days later than those fed corn. They required slightly less supplement and total feed per unit of gain produced. Since wheat contains approximately 2.5 per cent more protein than corn, less protein supplement is needed with it than with corn. The supplement taken made up 11 per cent of the wheat and 13 per cent of the corn ration. The corn ration averaged approximately 13.8 and the wheat ration, 14.6 per cent of protein.

In these tests, as determined from the amounts of the various feeds required per unit of gain, ground wheat was worth 7.6 per cent more than shelled corn.

A summary of eight dry-lot tests with shelled corn and two with ground corn, including the four at the Ohio Station (table 13) and six others of a similar nature at other stations, shows that the average worth of ground wheat was 4.9 per cent greater than that of shelled corn for growing and fattening pigs in dry lot. When the larger number of experiments was included, the daily feed consumed by the wheat-fed pigs and the rapidity of their gains were slightly greater than were those of the corn-fed pigs.

TABLE 13.—Ground wheat as a complete substitute for corn

	Corn Supplement	Ground wheat Supplement
Number of comparisons	4	4
Pigs at start	43	43
Initial weight per pig, lb.	62.5	63.1
Pigs at close	42	41
Final weight per pig, lb.	217.3	214.4
Average daily gain, lb.	**1.33**	**1.27**
Days required to gain 160 lb.	121	126
Daily feed per pig, lb.:		
Corn	4.63	.....
Wheat	.....	4.41
Tankage	.33	.25
Linseed meal	.15	.12
Ground alfalfa	.15	.12
Minerals	.07	.05
Total	5.34	4.95
Feed per 100-lb. gain, lb.:		
Corn	349.02*	.....
Wheat	.....	347.57
Tankage	25.07	20.21
Linseed meal	11.46	9.10
Ground alfalfa	11.46	9.10
Minerals	5.40	4.31
Total	**402.41**	**390.29**
Cost of feed per 100-lb. gain	$5.08	$6.32
Value of ground wheat with shelled corn as 100 per cent	.....	107.6%

*58.61 per cent, or 204.55 lb. per 100-lb. gain, of the corn was ground.

Owing chiefly, perhaps, to its higher protein content, ground wheat was worth considerably more than ground corn when both were fed without a protein supplement to growing pigs in dry lot. In a 70-day Ohio test with five 84-pound pigs to the lot, those given wheat gained 0.96 pound daily and consumed 469 pounds of wheat per 100 pounds of gain, whereas those given corn gained 0.64 pound daily and consumed 618 pounds of corn per 100 pounds of gain. In a test at the Maryland Station, ground wheat showed a higher value as compared with that of corn when one-eighth pound of fish meal daily a head was fed than when two-eighths or three-eighths pound of fish meal daily a head was fed with each. Apparently an eighth of a pound of fish meal came more nearly balancing the wheat than the corn.

A summary of an experiment at the Nebraska Station on Sudan grass and one at the Michigan Station on Dwarf Essex rape shows that for growing and fattening pigs on pasture the average value of ground wheat was 98.1 per cent that of shelled corn. The pigs fed ground wheat ate more feed and made faster gains but made less gain per unit of feed than those fed shelled corn.

In table 14 the data for the four Ohio experiments comparing wheat and corn are divided into a growing and a fattening period. Up to the time the pigs averaged approximately 140 pounds in weight, those receiving wheat, although they had taken slightly less feed daily a head, gained as rapidly as those receiving corn. During the growing period, the value of the ground wheat was 15 per cent greater than that of shelled corn.

During the fattening period, or from an average approximate weight of 140 to one of 215 pounds, the pigs fed wheat lacked 0.6 pound of taking as much feed daily a head as those fed corn. They gained less rapidly and also made less gain per unit of feed than those fed corn. For fattening, the ground wheat was worth 1.0 per cent more than shelled corn.

TABLE 14.—Comparisons of wheat and corn for growing pigs and for fattening shotes

	Growing period		Fattening period	
	Corn Supplement	Ground wheat Supplement	Corn Supplement	Ground wheat Supplement
Number of comparisons	4	4	4	4
Pigs at start	43	43	42	41
Initial weight per pig, lb.	62.5	63.1	138.8	140.7
Pigs at close	42	41	42	41
Final weight per pig, lb.	138.8	140.7	217.3	214.4
Average daily gain, lb.	1.07	1.08	1.74	1.55
Daily feed per pig, lb.:				
Corn	3.64	.....	6.20	.....
Wheat	.....	3.47	.....	5.85
Tankage	.31	.26	.37	.26
Linseed meal	.14	.11	.17	.12
Ground alfalfa	.14	.11	.17	.12
Minerals	.06	.06	.08	.05
Total	4.29	4.01	6.99	6.40
Feed per 100-lb. gain, lb.:				
Corn	341.02	.....	356.79	.....
Wheat	.....	319.99	.....	377.10
Tankage	28.94	23.65	21.32	16.53
Linseed meal	13.16	10.52	9.81	7.57
Ground alfalfa	13.16	10.52	9.81	7.57
Minerals	6.19	4.98	4.63	3.60
Total	**402.47**	**369.66**	**402.36**	**412.37**
Cost of feed per 100-lb. gain	$5.14	$6.00	$5.01	$6.66
Value of ground wheat with shelled corn as 100 per cent	.....	115.0%	.....	101.0%

In the growing period, 63.46 per cent, or 216.42 lb. per 100 lb. of gain, of the corn was ground.

In the fattening period, 54.11 per cent, or 193.05 lb. per 100 lb. of gain, of the corn was ground.

The relatively greater value of wheat as compared with corn for growing than for fattening pigs is also brought out by the results of tests in which the pigs were placed on feed when under 100 pounds in weight as contrasted with the results of those in which shotes weighing 100 pounds or more when the experiments were started were used. As mentioned previously, in 10 dry-lot experiments with growing and fattening pigs having an average initial weight of approximately 60 pounds, the average value of ground wheat was 4.9 per cent greater than that of shelled corn. In 10 dry-lot experiments with shotes having an average initial weight of approximately 106 pounds, the value of ground wheat was 98.1 per cent that of shelled corn.

Whole and ground wheat were compared in six trials at other stations for self-feeding with a supplement to growing and fattening pigs that were carried from approximately 69 to 200 pounds in average weight. The pigs on the whole and those on the ground wheat gained 1.42 and 1.44 pounds daily a head and required 402 and 386 pounds of feed per 100 pounds of gain, respectively. The ground wheat was worth 5.5 per cent more than the whole wheat.

In similar self-feeding comparisons with heavier shotes, carried from approximately 130 to 225 pounds in weight, grinding increased the feeding value of the wheat 5.1 per cent.

In five trials in which shotes averaging approximately 125 pounds in weight when they were placed on feed were used, but in which the feeds were given twice daily, ground wheat was worth 16.8 per cent more than whole wheat.

The shotes given ground wheat not only required less feed per unit of gain but also took more feed and made 0.26 pound more gain daily a head than those given whole wheat. In a hand-feeding trial at the Nebraska Station with growing and fattening pigs on Sudan grass pasture, an even higher value, as compared with that of whole wheat, was obtained for the ground wheat.

These summaries indicate that it would pay to grind wheat for pigs that are hand-fed but not for those that are self-fed, unless the price is high or the cost of grinding low. Apparently, pigs that are fed twice daily are inclined to bolt their feed, whereas those that are self-fed eat their feed more leisurely and masticate it more thoroughly, so that the advantage of grinding is less.

Soaking whole wheat brought about no increase in its feeding value.

In trials at the Michigan Station three different finenesses of ground wheat showed no consistent variations in their feeding value. Usually, crushing or coarse grinding is considered preferable to grinding more finely. For the purpose of overcoming its pastiness when masticated, due to the gluten contained, corn or oats are sometimes mixed with the wheat, especially if the wheat is finely ground. If the pastiness of the wheat were a serious handicap, such excellent results from feeding wheat as the only grain would not be obtained. In tests at the Missouri and Maryland Stations there was no particular advantage in feeding a combination of corn and wheat. If wheat is cheaper than corn, substituting it for all rather than for only a part of the corn is advisable. If a mixture of corn and wheat is used, however, it would be expected to show up to better advantage for shotes than for younger pigs. In case oats are mixed with wheat, 1 pound or less to 3 of the wheat would be preferable to a larger amount. Pigs in dry lot would perhaps give a better response to the mixture than pigs on pasture or fattening shotes.

WHEAT MIDDLINGS

Wheat middlings are a popular feed for swine. In the milling of wheat the coarse or outer covering of the kernel, or bran, and various grades of middlings or shorts are obtained as by-products. The middlings or shorts are designated by different terms, depending on the process of milling and what by-products of the wheat kernel are included or excluded in their manufacture.

"Standard middlings consist mostly of fine particles of bran, germ, and very little of the fibrous offal obtained from the tail of the mill. This product must be obtained in the usual commercial process of milling and must not contain more than 9.5 per cent of crude fiber."

"Wheat red dog is a by-product obtained in the usual commercial process of flour milling, consisting principally of the aleurone (that is, the fourth layer of the kernel) with small quantities of wheat flour and fine wheat bran particles, and must not contain more than 4.0 per cent of crude fiber."

"Flour middlings consist of standard middlings and red dog combined in the proportions obtained in the usual process of milling and must not contain more than 6 per cent of crude fiber."

Brown shorts or red shorts are similar to standard middlings except that they must not contain more than 7.5 per cent of crude fiber. Gray shorts or middlings, like flour middlings, must not contain more than 6 per cent of crude fiber. White shorts or white middlings must not contain over 3.5 per cent of crude fiber.

Middlings may be divided roughly into two general classes, one containing more and the other less than 6 per cent of crude fiber. For convenience, although it would not be in strict compliance with the quoted definitions of the Association of American Feed Control Officials, the feeder might think of them as the standard middlings class and the flour middlings class, respectively.

Only two trials were conducted in which wheat middlings were used as a complete substitute for corn. In one of these, standard middlings were fed to pigs having an average initial weight of approximately 70 pounds. In the other, flour middlings were fed to pigs which averaged slightly over 100 pounds in weight at the start.

TABLE 15.—Wheat middlings as a complete substitute for corn, in dry lot

	For growing and fattening pigs		For fattening shotes	
	Ground corn Tankage	Standard middlings Tankage	Ground corn Tankage	Flour middlings Tankage
Number of comparisons	1	1	1	1
Pigs at start	5	5	5	5
Initial weight per pig, lb.	68	69	102	111
Pigs at close	5	5	5	5
Final weight per pig, lb.	180	178	245	250
Average daily gain, lb.	1.22	1.04	1.57	1.52
Days required to gain 160 lb.	132	154	102	106
Daily feed per pig, lb.:				
Corn	4.74	.....	5.23	.....
Middlings	.....	4.36	.....	5.16
Tankage	.59	.63	.58	.57
Total	5.33	4.99	5.81	5.73
Feed per 100-lb. gain, lb.:				
Corn	387.42	.....	329.83	.....
Middlings	.....	419.71	.....	335.16
Tankage	48.34	60.40	36.65	37.24
Total	**435.76**	**480.11**	**366.48**	**372.40**
Cost of feed per 100-lb. gain	$5.83	$6.40	$4.87	$5.53
Value of middlings with shelled corn as 100 per cent	.....	90.2%	.....	102.0%

Fattening shote data taken from Bulletin 268.

When both were supplemented with tankage, standard middlings produced gains 85 per cent as rapidly as corn. As determined from the corn and tankage replaced per unit of gain, the standard middlings were worth 90.2 per cent as much a pound as shelled corn.

On the heavier shotes, flour middlings produced gains 97 per cent as rapidly as corn. In the one trial in which they were used as a complete substitute for corn, they were worth 2 per cent more than shelled corn.

Standard middlings were fed as a complete substitute for corn in an experiment on bluegrass and in one on rape pasture at the Iowa Station. There the pigs gained 81.5 per cent as rapidly as those on corn. With the corn and tankage at the prices used in this report, a value 86 per cent that of shelled corn was obtained for the standard middlings.

Flour middlings were also substituted for all of the corn in the ration for pigs on rape pasture in one trial at the Iowa Station. In this test the flour middlings showed a value 96 per cent as great a pound as that of shelled corn. The pigs receiving flour middlings made even faster gains than those receiving corn. The pigs were carried from approximately 40 to 225 pounds in weight.

The two general types of middlings do not differ greatly in their protein content. Both contain a little less than twice as much as corn. Previous to the time higher protein feeds were as common as at present, middlings were used extensively as a supplement to corn. Middlings, like the grains, are deficient in minerals. They are also deficient in vitamins A and D. Furthermore, a large percentage of middlings is needed in the ration to supply the protein recommended by feeding standards. Middlings are more suitable for serving as a partial substitute for both the carbonaceous feed and the protein concentrate in the ration than as a complete substitute for the protein supplement.

Table 16 summarizes four dry-lot experiments in which flour middlings were fed along with corn and a protein supplement. The pigs given the middlings consumed a little more feed per unit of gain than the others, but, since a smaller amount of tankage was required when they were included in the ration, the value obtained for the flour middlings was 7 per cent greater than that of an equal weight of shelled corn.

TABLE 16.—Flour wheat middlings as a partial substitute for corn

	Corn Supplement	Corn Flour wheat middlings Supplement
Number of comparisons	4	4
Pigs at start	26	28
Initial weight per pig, lb.	77.1	77.2
Pigs at close	26	27
Final weight per pig, lb.	216.4	211.9
Average daily gain, lb.	1.29	1.25
Days required to gain 160 lb.	125	128
Daily feed per pig, lb.:		
Corn	4.77	3.92
Middlings	.....	1.03
Tankage	.44	.29
Linseed meal	.04	.....
Ground alfalfa	.03	.02
Minerals	.02	.02
Total	5.30	5.28
Feed per 100-lb. gain, lb.:		
Corn	370.67	312.79
Middlings	.....	82.04
Tankage	33.97	22.69
Linseed meal	3.48	.....
Ground alfalfa	2.10	1.75
Minerals	1.86	1.60
Total	**412.08**	**420.87**
Cost of feed per 100-lb. gain	$5.22	$5.35
Value of middlings with shelled corn as 100 per cent	.....	107.0%

46.92 per cent, or 173.92 lb. per 100 lb. of gain, of the corn fed without middlings, and 40.22 per cent, or 125.81 lb. per 100 lb. of gain, of the corn fed with middlings were ground.

A summary including a dry-lot and three pasture experiments at other stations, as well as the four experiments reported in table 16, or a total of eight tests, in which flour middlings were used as a partial substitute for both the corn and the protein supplement, shows that the average value of the flour middlings was 103.0 per cent that of shelled corn.

In 10 trials in which standard middlings were fed in a similar manner, they showed an average value 87.7 per cent that of shelled corn. The summaries of the larger number of experiments show that pigs given middlings, regardless of whether flour or standard middlings were used, ate more feed daily a head and gained more rapidly than those on similar rations without the middlings. The

middlings, however, failed to increase the amount of gain from a given quantity of feed. The difference in the rate of growth would have enabled the pigs given flour middlings and those given standard middlings to be marketed 4 days and 6 days earlier, respectively, than those without them.

Only one experiment was conducted in which a direct comparison of flour and standard middlings was made. The flour middlings constituted 15 and the standard middlings 18 per cent of the total ration, the other ingredients of which were yellow corn, tankage, ground alfalfa, and minerals. The flour middlings contained 15.6 per cent of protein, 4.4 per cent of fiber, and 3.4 per cent of fat, and the standard middlings 15.7 per cent of protein, 6.2 per cent of fiber, and 6.2 per cent of fat.

TABLE 17.—Comparison of flour and standard wheat middlings for pigs

Feeds mixed Pigs full-fed twice daily	Corn **Flour middlings** Tankage Ground alfalfa Minerals	Corn **Standard middlings** Tankage Ground alfalfa Minerals
Pigs at start	6	6
Initial weight per pig, lb	65.4	65.1
Pigs at close	5	6
Final weight per pig, lb	211.9	207.7
Average daily gain, lb	.99	1.07
Days required to gain 160 lb	162	150
Daily feed per pig, lb.:		
Corn, ground	3.16	3.31
Middlings	.62	.81
Tankage	.21	.27
Linseed meal		
Ground alfalfa	.09	.09
Minerals	.06	.07
Total	4.14	4.54
Feed per 100-lb. gain, lb.:		
Corn, ground	319.60	309.04
Middlings	62.74	76.14
Tankage	21.30	23.02
Linseed meal		
Ground alfalfa	8.37	8.46
Minerals	6.27	6.35
Total	418.28	423.01
Cost of feed per 100-lb. gain	$5.47	$5.42
Value of standard middlings with flour middlings at 1.4 cents per lb.		1.26¢
Value of standard middlings with flour middlings as 100 per cent		90.1%

Although they took 0.4 pound more feed daily a head and gained 8 per cent more rapidly, the pigs fed standard middlings required a trifle more feed per unit of gain than did those fed flour middlings. A value 90.1 per cent as great as that of the flour middlings was obtained for the standard middlings.

In two trials on alfalfa pasture, at the Minnesota Station, in which both the flour and standard middlings made up 30 per cent of their respective rations until the pigs averaged 100 pounds in weight and 23 per cent thereafter, the standard middlings were worth 85.1 per cent as much as the flour middlings. The flour middlings were 0.1 per cent lower and the standard middlings 0.5 per cent higher in fiber than were those used in the Ohio trial.

The feeding value of wheat middlings fed under similar conditions varies greatly, depending upon the quality of the middlings. Lowness in fiber is a fairly reliable indication of the relative worth of different samples of middlings for growing and fattening pigs.

"PALMO MIDDS"

"Palmo Midds" are a by-product of the manufacture of tin plate. Palm oil is used in polishing the tin plate and middlings are employed to remove the excess oil. When the middlings have absorbed so much oil that they are no longer suitable for the purpose, the oil-bearing middlings are cleaned and marketed for livestock feeding.

TABLE 18.—Comparison of flour wheat middlings and "Palmo Midds" as the only carbonaceous feed for pigs

	Flour middlings Tankage	"Palmo Midds" Tankage
Number of comparisons	3	3
Pigs at start	16	16
Initial weight per pig, lb	81	80
Pigs at close	15	15
Final weight per pig, lb	143	141
Average daily gain, lb	**1.06**	**.91**
Days required to gain 160 lb	151	176
Daily feed per pig, lb.:		
Flour middlings	3.89	.....
"Palmo Midds"	.....	4.01
Tankage	.24	.24
Total	4.13	4.25
Feed per 100-lb. gain, lb.:		
Flour middlings	366.05	.....
"Palmo Midds"	.....	440.87
Tankage	21.97	26.01
Total	**388.02**	**466.88**
Cost of feed per 100-lb. gain	$5.62	$5.88
Value of "Palmo Midds" as compared with flour middlings at 1.4 cents per lb	.....	1.08¢
Value of "Palmo Midds" as compared with flour middlings as 100 per cent	.....	77.0%

Table 18 summarizes three dry-lot trials in which rations of flour middlings and tankage, and "Palmo Midds" and tankage were compared for pigs which averaged approximately 80 pounds in weight when they were placed on feed. Although the pigs fed "Palmo Midds" ate a little more feed than those fed flour middlings, they gained 14.2 per cent less rapidly and required 20.3 per cent more feed per unit of gain. Considering only the feed required per unit of gain, the "Palmo Midds", used as the only carbonaceous feed in the ration, were worth 77 per cent as much as the flour middlings.

Table 19 gives the results of two experiments in which standard middlings and "Palmo Midds" were used as partial substitutes for corn. In the first experiment the middlings and "Palmo Midds" each made up 25 per cent of their respective rations, which otherwise consisted of corn and tankage. Flake salt was fed separately. The pigs averaged approximately 95 pounds in weight at the beginning of the test and were kept indoors on a concrete floor. The standard middlings were obtained from a local mill and were of average quality.

For the first 8 weeks, although they consumed no more feed, the pigs on the ration containing the standard middlings made slightly faster gains and required 27 pounds less feed per 100 pounds of gain than those fed merely corn and tankage. Later some of them became stiff or crampy, so that by the end of 12 weeks their average daily gain was a tenth of a pound less and their feed consumption per 100 pounds of gain 10 pounds higher than were those of the group fed corn and tankage.

TABLE 19.—"Palmo Midds" as a partial substitute for corn

	When constituting 25 per cent of the ration			When constituting 18 per cent of the ration		
	Corn Tankage	Corn Standard middlings Tankage	Corn "Palmo Midds" Tankage	Corn Linseed meal Tankage Ground alfalfa Minerals	Corn Standard middlings Tankage Ground alfalfa Minerals	Corn "Palmo Midds" Tankage Ground alfalfa Minerals
Pigs at start	8	8	8	6	6	6
Initial weight per pig, lb.	94	95	95	65	65	65
Pigs at close	8	8	8	6	6	6
Final weight per pig, lb.	192	184	170	226	220	227
Average daily gain, lb.	1.16	1.06	.90	1.15	1.10	1.16
Days required to gain 160 lb.				140		138
Daily feed per pig, lb.:						
Corn	4.45	3.21	3.19	3.93	3.43	3.48
Middlings		1.14			.84	
"Palmo Midds"			1.15			.87
Tankage	.44	.20	.25	.30	.25	.28
Linseed meal				.15		
Ground alfalfa				.09	.10	.10
Minerals	.01	.02	.01	.07	.07	.07
Total	4.90	4.57	4.60	4.54	4.69	4.80
Feed per 100-lb. gain, lb.:						
Corn	383.39	303.84	355.43	340.95	310.36	301.49
Middlings		107.66			76.40	
"Palmo Midds"			127.73			74.74
Tankage	37.85	19.16	27.77	26.00	22.85	24.49
Linseed meal				13.00		
Ground alfalfa				7.87	8.49	8.30
Minerals	1.32	1.51	1.36	5.91	6.37	6.23
Total	**422.56**	**432.17**	**512.29**	**393.73**	**424.47**	**415.25**
Cost of feed per 100-lb. gain	$5.57	$5.48	$6.54	$5.15	$5.44	$5.34
Value of middlings with shelled corn as 100 per cent		111.3%	38.5%		70.9%	80.9%

The "Palmo Midds" gave relatively poor results from the beginning of the experiment. During the first 8 weeks the pigs ate 3 per cent less feed than those fed the standard middlings, but by the close of the test, because of the low feed consumption of the crampy pigs in the standard-middlings lot, they had consumed a slightly greater amount of feed daily a head. After having been on feed for 14 weeks, some of them, and one in the corn and tankage group likewise, showed some crampiness. The data presented are for the first 12 weeks of the feeding period. A relatively low value was obtained for the "Palmo Midds" in this experiment in which they made up 25 per cent of the total ration.

In the second experiment the check ration was composed of corn, tankage, linseed meal, ground alfalfa, and minerals. The middlings and "Palmo Midds" were used to make up 18 per cent of the total feed. In the rations containing one or the other of these, the linseed meal was omitted and the tankage reduced so that the total protein was approximately the same. The pigs were full-fed twice daily and confined indoors as in the previous test. The standard middlings were similar to those used in the manufacture of "Palmo Midds" and were obtained from the same company as the latter. They contained 6.21 per cent of fiber and 6.25 per cent of fat. Perhaps they should have been classified as choice, fine middlings, which is the grade between standard and flour middlings. The "Palmo Midds" contained 7.03 per cent of fiber and 9.78 per cent of oil.

With each constituting 18 per cent of their respective rations, "Palmo Midds" produced 5 per cent faster gains on 2 per cent less feed per unit of gain than the standard middlings.

When they were fed at the rate of about one-fifth of the ration, the feeding value of middlings was apparently not impaired by the middlings' having been used to absorb palm oil in the polishing of tin plate.

"Palmo Midds", however, were not very satisfactory when they were fed in large amounts.

Since these tests were conducted, an improved method of removing the oil from tin plate has come into use. This method leaves less oil to be absorbed from the plate but necessitates the use of an absorbent of higher quality. It is claimed that middlings containing considerable red-dog flour and running 4 per cent or less in fiber now go into the manufacture of "Palmo Midds" and that the feeding value of the "Palmo Midds" is correspondingly higher.

COCOANUT OIL MEAL

Cocoanut oil meal, or copra oil meal, as defined by the Association of Feed Control Officials, is the ground residue from the extraction of a part of the oil from the dried meat of the cocoanut. The average composition of cocoanut oil meal is approximately 22 per cent protein, 8 per cent fat, 9 per cent crude fiber, 5.5 per cent ash, and 45 per cent nitrogen-free extract.

The results of two tests with cocoanut oil meal are reported in table 20.

Cocoanut oil meal was fed at the rate of 15 per cent of the ration in the first trial. Less tankage and no linseed meal were included in the ration with it. The two rations contained approximately equivalent amounts of total protein. The pigs fed the ration containing cocoanut oil meal made slightly faster gains but required a trifle more feed per unit of gain than those fed the check ration. Nevertheless, because it replaced a part of the relatively high-priced protein concentrate, the cocoanut oil meal showed a value 15 per cent greater than that of shelled corn.

The second trial was carried on in cooperation with the Procter and Gamble Company. Each lot originally contained 15 purchased pigs. The pigs were first placed on feed when they averaged 35 pounds in weight. Apparently they had not yet completely recovered from the effects of immunization against cholera. A few died and others gained very slowly for a few weeks. The data presented were summarized from average initial weights of approximately 45 pounds. This did not alter the relative standings of the various lots. The check group in this test was fed corn, meat and bone scraps, linseed meal, ground alfalfa, and minerals.

Lot 2 was fed a ration containing 25 per cent of cocoanut oil meal. The meat and bone scraps and the linseed meal were reduced in this ration so that the total protein in it and in the check ration was approximately the same. A value 2 per cent greater a pound than that of shelled corn was obtained for the cocoanut oil meal when it was fed in this way.

Lot 3 was fed a ration containing 40 per cent of cocoanut oil meal. The meat and bone scraps and the linseed meal in it were kept at the same level as in the check ration. Stated differently, the cocoanut oil meal replaced about half of the corn but no protein supplement. Fed in this way, the average worth of the cocoanut oil meal was 84.5 per cent as much a pound as that of shelled corn. During the growing period, or until the pigs averaged approximately 125

TABLE 20.—Cocoanut oil meal as a partial and complete substitute for corn for pigs in dry lot

	Experiment 1, started Dec. 6, 1927		Experiment 2, started July 14, 1937				
	1 Corn Tankage Linseed meal Ground alfalfa Minerals	2 Corn **Cocoanut oil meal** Tankage Ground alfalfa Minerals	1 Corn Meat and bone scraps Linseed meal Ground alfalfa Minerals	2 Corn **Cocoanut oil meal** Meat and bone scraps Linseed meal Ground alfalfa Minerals	3 Corn **Cocoanut oil meal** Meat and bone scraps Linseed meal Ground alfalfa Minerals	4 Corn **Cocoanut oil meal** Ground alfalfa Minerals	5 **Cocoanut oil meal** Skimmed milk Ground alfalfa Minerals
Cocoanut oil meal in ration, per cent	.....	15	.....	25	40	56.4	77.9*
Ratio of cocoanut oil meal to corn	.....	1:5.1	.....	1:2.6	1:1.0	1.5:1	.....
Number of pigs	6	6	14	13	15	11	13
Initial weight per pig, lb.	65.1	64.8	45.0	46.4	46.8	49.1	49.1
Final weight per pig, lb.	226.5	233.2	198.9	196.2	195.3	78.1	195.9
Average daily gain, lb.	1.15	1.20	1.22	1.02	1.06	.41	.95
Days required to gain 160 lb.	140	134	132	157	151	391	169
Daily feed per pig, lb.:							
Corn	3.93	3.68	3.94	2.74	1.87	1.10	.....
Cocoanut oil meal	.....	.72	.....	1.06	1.83	1.65	3.28
Skimmed milk	.....	.....	.....	.....	.....	.....	6.85†
Tankage or meat and bone scraps	.30	.22	.48	.17	.44	.....	.....
Linseed meal	.15	.....	.24	.09	.22	.....	.....
Ground alfalfa	.09	.10	.19	.17	.18	.12	.17
Minerals	.07	.07	.02	.02	.02	.06	.04
Total	4.54	4.79	4.87	4.25	4.56	2.93	4.22*
Feed per 100-lb. gain, lb.:							
Corn	340.95	305.74	322.21	269.02	176.14	266.74	.....
Cocoanut oil meal	.....	59.67	.....	104.28	171.75	400.11	346.91
Skimmed milk	.....	.....	.....	.....	.....	.....	723.12†
Tankage or meat and bone scraps	26.00	18.49	39.14	16.71	41.56	.....	.....
Linseed meal	13.00	.....	19.57	8.35	20.78	.....	.....
Ground alfalfa	7.87	7.95	15.95	16.68	17.17	28.38	18.45
Minerals	5.91	5.97	1.85	2.09	1.97	14.19	3.69
Total	393.73	397.82	398.72	417.13	429.37	709.42	445.55*
Cost of feed per 100-lb. gain	$5.15	$5.25	$5.16	$5.49	$6.02	$9.81	$6.12
Value of cocoanut oil meal with shelled corn as 100 per cent	.....	115.3%	.....	102.3%	84.5%	29.3%	79.7%

*With the skimmed milk on a basis of 10 per cent moisture.

†Liquid skimmed milk was fed for 84 days. Since no source of liquid milk was found thereafter, dried skimmed milk was fed for the remaining 70 days. A total of 270 pounds was fed. In the figures, the dried milk has been converted to its liquid milk equivalent. The solids in the dried milk were figured at the same cost as those in the liquid milk rather than at actual cost.

pounds in weight, the cocoanut oil meal, when used in this way and when used at the 25 per cent level, to replace a part of both the corn and the protein concentrate, was worth 118 and 110 per cent, respectively, as much a pound as shelled corn. The values obtained for the cocoanut oil meal after the pigs averaged 125 pounds in weight were 87 per cent that of shelled corn when cocoanut oil meal was fed at the 25 per cent level in place of both a part of the corn and a part of the protein concentrate, and 63 per cent that of shelled corn when it was fed at the 40 per cent level in place of a part of the corn only. As would be anticipated, the bulkiness of the cocoanut oil meal was less detrimental during the growing than during the fattening period.

A fourth group was started on a ration containing no meat and bone scraps or linseed meal but sufficient cocoanut oil meal to make the protein content approximately the same as that of the check ration. During the growing period, this was 1.5 times as much cocoanut oil meal as corn. The pigs in this group did so poorly that when they averaged 78 pounds in weight they were divided and changed to the same rations as those fed Lots 1 and 3. Up to the time their feed was changed, they gained only 0.4 pound daily a head and took 709 pounds of feed per 100 pounds of gain. From then until they reached a weight of 200 pounds, those fed the check ration gained 1.76 pounds daily a head and took 366 pounds of feed per 100 pounds of gain. Those with 40 per cent of cocoanut oil meal substituted for an equal percentage of corn gained 1.41 pounds daily a head and required 411 pounds of feed per 100 pounds of gain produced. A value 74 per cent that of shelled corn a pound was obtained for the cocoanut oil meal fed them. As would be expected, since a part of the growing period was included, this was higher than the value of 63 per cent that of corn a pound obtained for the cocoanut oil meal fed Lot 3 during the fattening period.

The fifth group received cocoanut oil meal as a complete substitute for corn. The meat and bone scraps and the linseed meal were replaced with skimmed milk. After the first 84 days, no source of liquid milk was found; hence, for the remaining 70 days, dried skimmed milk was fed. For the period during which liquid milk was fed, a value 92 per cent that of shelled corn a pound was obtained for the cocoanut oil meal. During the time dried milk was fed, the cocoanut oil meal showed a value 72 per cent that of shelled corn a pound. The solids in the dried milk were figured at the same price a pound as those in the liquid milk rather than at cost. Doubtless a part of the difference in the worth of the cocoanut oil meal for the two periods was due to the greater detriment of the bulky ration during the fattening than during the growing period.

Apparently factors working against a more favorable showing for cocoanut oil meal when it was fed to growing and fattening pigs were its relatively high fiber content and the failure of its proteins to supplement adequately those of corn. Cocoanut oil meal showed a higher value when fed at a level not exceeding 25 per cent than when fed in larger amounts and when fed in place of both a part of the corn and a part of the protein concentrate than when fed in place of either all the corn or all the protein concentrate.

Cocoanut oil meal is higher in oil than corn. Since the oil is a solid at ordinary temperatures, the meal supposedly does not have a tendency to produce pork that is lacking in firmness.

Cocoanut oil meal was kept in sacks in an ordinary barn loft for more than a year without becoming rancid or showing evidence of a decrease in palatability when fed to pigs.

RICE BY-PRODUCTS

In the milling process, rice is first cleaned and then, to remove the outer hull or husk, is passed between a pair of grooved stones, the upper one of which revolves. One operation does not remove the hulls from all the grains. In the next step, most mills use a revolving screen, which is known as the stone bran reel, to remove the fine particles of bran and hull and also the broken pieces of kernel. A paddy or unhulled rice machine then separates the brown or hulled rice from what has been left unhulled and the latter is passed through a pair of auxiliary stones and from there back into the stone bran reel or main stream.

The brown or hulled rice goes on to a huller, which is improperly named, as its purpose is to remove the outer bran layers. The loosened bran is separated by what is termed the first break reel. For the removal of the inner bran coatings, the rice goes from there, in some mills, to other hullers, and in other mills to what is known as a pearling cone. To polish the rice or give it a smoother finish, it is next put through a brush machine which consists of a leather-padded vertical cylinder that revolves within a wire screen.

Rice carries seven distinct layers of bran. Milling removes all but a part of the inner or aleurone layer from the starchy portion of the kernel. The by-products obtained in milling are (1) the outer hulls, (2) the stone bran, which consists of some outer bran, an unavoidable amount of hull particles, some broken germs, and, sometimes, a little finely broken rice, (3) the huller bran, which is secured from the huller and pearling cones and which consists mostly of the bran and germs, and (4) the polish. Commercial rice bran is frequently made up of a mixture of stone bran and huller bran. The inner finer particles of bran, together with a portion of the polish, are removed by the pearling cone. By the definition of the Association of Feed Control Officials, the resulting meal is classified under huller bran. The pearling cone meal or bran is sometimes sold separately and sometimes mixed with the other bran.

The average yields of products from rice of the Blue Rose variety, as reported by Fraps in Bulletin 191 of the Texas Agricultural Experiment Station, were: hulls, 17.9, bran, 8.0, polish, 2.5, fancy rice, 57.4, second rice, 3.1, brewers' rice, 2.5, screenings, 5.5, and dirt and loss, 3.1 per cent. Table 21 shows the composition of various rice products as given in the same publication.

Most of the oil or fat in rice is contained in the germ. Consequently a relatively high or low fat content in a rice product is indicative of the presence of a relatively large or a relatively small percentage of the germ.

TABLE 21.—Composition of rice products*

	Number averaged	Water	Ash	Protein	Carbohydrates		Fat
					Fiber	Nitrogen-free extract	
Rice hulls	14	8.49	18.59	3.56	39.05	29.38	0.93
Stone bran†	12	9.35	16.07	9.60	22.33	34.49	8.16
Huller bran†	10	9.65	7.38	15.29	8.47	38.13	18.78
Pearling cone bran	8	9.77	7.08	15.39	5.66	46.13	15.97
Mixed bran	18	9.78	9.98	13.63	11.69	40.14	14.78
Rice polish	10	9.91	4.21	12.88	2.12	61.81	9.07
Brewers' rice	9	11.78	.79	8.88	.56	77.14	.95
Head rice	8	12.57	.50	9.01	.40	77.02	.50

*From Bulletin 191, Texas Agricultural Experiment Station.
†From Blue Rose variety of rice.

In samples analyzed by Fraps, the fiber in the outer woody hulls of rice ranged from 31 to 46 per cent. The fiber in the huller or inner bran averaged 7.9 per cent and that in the outer or stone bran 20.9 per cent. That in the residue of the stone bran, after the hull was deducted, was 8 per cent. Fourteen out of eighteen samples of mixed bran ranged from 7.2 to 13.4 and averaged 10.5 per cent of fiber. The four omitted contained from 14.3 to 17.8 per cent. If mixed rice bran has a fiber content much in excess of 11 or 12 per cent, it may be suspected of containing more hull than the unavoidable amount left in the stone bran in the regular milling of rice.

Stone bran and mixed bran are too fibrous in character to give optimum results if used for making up a large share of a growing and fattening ration for pigs. Huller bran and particularly pearling cone bran are lower in fiber and more suitable in this respect for the feeding of pigs. The fiber content of rice polish is relatively low.

Rice bran and rice polish are rather high in fat. Both have a tendency to produce soft pork if they make up a very large share of the ration, as they sometimes do in rice-producing areas. In Morrison's "Feeds and Feeding" the average amounts of fat in rice bran and rice polish are given as 13.4 and 11.5 per cent, respectively. Inasmuch as 5.5 per cent of softening fats is about the maximum in a ration that can be fed constantly without producing objectionably soft pork, unless their fat contents are below the average, not more than 16 per cent of rice polish or 12.5 per cent of rice bran can be incorporated in a corn and tankage ration with safety, so far as the production of pork of a satisfactory degree of firmness is concerned.

RICE MIXED BRAN

In a dry-lot experiment with pigs having an average initial weight of 57 pounds, a half-pound of rice bran daily a head was fed along with a ration of yellow corn, linseed meal, and minerals. The rice bran averaged 12 per cent of the total feed. The pigs fed the bran ate a third of a pound more total feed daily a head, gained 24 per cent more rapidly, and required 11.8 per cent less feed per unit of gain than those with which they were compared. The faster gains would have enabled the pigs fed the rice bran to be marketed 6 weeks earlier than those without it. Apparently rice bran was instrumental in changing a fairly efficient ration into one of high efficiency. Probably for this reason, the rice bran showed a value 221.9 per cent that of shelled corn when it was fed at the 12 per cent level with corn, linseed meal, and minerals.

RICE PEARLING CONE BRAN

Feeding rice pearling cone bran with a ration of yellow corn, linseed meal, and minerals was tried in three dry-lot experiments with growing and fattening pigs. The amount used averaged 11 per cent of the total feed. The pigs fed the pearling cone bran ate 27.3 per cent more feed daily a head, made 44.4 per cent faster gains, and required 11.6 per cent less feed per unit of gain than those fed an otherwise similar ration. The value of the pearling cone bran as determined by considering only the feed required per unit of gain was 232.2 per cent that of shelled corn.

RICE POLISH

Three experiments were likewise conducted in which rice polish was added to similar rations. The amount fed averaged 13 per cent of the total feed. The pigs given the ration containing rice polish ate 21.4 per cent more feed

TABLE 22.—Rice by-products as a partial substitute for corn with linseed meal as the supplement

	Part 1		Part 2		Part 3	
	Corn Linseed meal Minerals	Corn Rice bran Linseed meal Minerals	Corn Linseed meal Minerals	Corn Rice pearling cone bran Linseed meal Minerals	Corn Linseed meal Minerals	Corn Rice polish Linseed meal Minerals
Per cent of rice by-product in ration	.....	13.2	.....	11.4	.....	13.1
Number of comparisons	1	1	3	3	3	3
Pigs at start	5	5	16	16	17	17
Initial weight per pig, lb.	57.1	57.2	60.4	60.6	44.9	45.0
Pigs at close	5	5	15	16	17	17
Final weight per pig, lb.	150.4	153.8	190.7	203.7	183.9	187.6
Average daily gain, lb.	.74	.92	.90	1.30	.76	1.06
Days required to gain 160 lb.	217	174	178	124	211	151
Daily feed per pig, lb.:						
Corn, ground	2.86	2.72	3.22	3.58	2.83	2.97
Rice by-product	.....	.50	.....	.55	.....	.54
Linseed meal	.48	.45	.54	.65	.48	.51
Minerals	.10	.10	.08	.11	.10	.12
Total	3.44	3.77	3.84	4.89	3.41	4.14
Feed per 100-lb. gain, lb.:						
Corn, ground	386.66	295.73	357.22	275.96	371.67	279.68
Rice by-product	.....	54.35	.....	42.73	.....	51.22
Linseed meal	64.45	49.29	59.54	49.93	63.12	47.99
Minerals	13.95	10.67	9.20	8.13	13.45	11.48
Total	**465.06**	**410.04**	**425.96**	**376.75**	**448.24**	**390.37**
Cost of feed per 100-lb. gain	$5.98	$5.23	$5.45	$4.89	$5.77	$5.14
Value of rice by-product with shelled corn as 100 per cent	.....	221.9%	.....	232.2%	.....	233.0%

daily a head, gained 39.5 per cent more rapidly, and consumed 12.9 per cent less feed per unit of gain than those fed a similar ration except for the rice polish. The value shown by the rice polish was 233 per cent that of shelled corn.

Although compared with similar rations, the rice pearling cone bran and the rice polish were not fed in the same experiments; that is, the control groups in the two sets of three comparisons each were not identical.

Including 10 per cent of rice polish in a ration of corn, tankage, and minerals for growing and fattening pigs in dry lot was tried in one experiment. Although the beneficial effect was not as pronounced as when linseed meal served as the protein concentrate, slightly faster gains and slightly greater gains per unit of feed were secured than were obtained from the same ration with the rice polish omitted. Used in this way, the rice polish was worth 145 per cent as much as the shelled corn.

In the experiments in which linseed meal was fed as a protein concentrate, the values obtained for the pearling cone bran and the mixed bran were 99.7 and 95.2 per cent as great, respectively, as the value obtained for the rice polish. On a basis of the same relationship, the pearling cone bran would be worth 145 per cent, and the mixed bran 138 per cent, as much as ground corn for including in a ration of corn, tankage, and minerals.[2]

[2]In a recent trial (1939) rice mixed bran, fed at a 12 per cent level with yellow corn, tankage, soybean oil meal, ground alfalfa, and minerals, was worth 13 per cent more a pound than shelled corn. The pigs in the check group were ready for market 14 days earlier than those fed rice bran.

TABLE 23.—Rice polish as a partial substitute for corn with tankage as the supplement

	Corn Tankage Minerals	Corn Rice polish Tankage Minerals
Number of comparisons	1	1
Pigs at start	6	6
Initial weight per pig, lb	40.1	39.7
Pigs at close	6	5
Final weight per pig, lb	202.9	200.8
Average daily gain, lb	1.16	1.22
Days required to gain 160 lb	138	132
Daily feed per pig, lb.:		
Corn, ground	3.76	3.40
Rice polish	.....	.42
Tankage	.34	.33
Minerals	.06	.06
Total	4.16	4.21
Feed per 100-lb. gain, lb.:		
Corn, ground	322.70	278.94
Rice polish	.....	34.57
Tankage	29.20	27.01
Minerals	5.36	5.19
Total	357.27	345.71
Cost of feed per 100-lb. gain	$4.72	$4.65
Value of rice polish with shelled corn as 100 per cent	.....	145.2%

COCOA BEAN OIL MEAL

Cocoa bean oil meal is the by-product left after the oil or "cocoa butter" has been pressed from cocoa beans for the manufacture of chocolate and breakfast cocoa. Table 24 gives the results of an experiment in which an attempt was made to substitute cocoa bean oil meal for all of the linseed meal and a part of the corn and tankage in a ration composed of corn, the trio supplemental mixture, and minerals. The experiment was previously reported in Bulletin 488, but, since the cocoa bean meal was tried as a partial substitute for corn, it is also reported here.

Cocoa bean oil meal was not satisfactory for pigs. It was fed at a 15 per cent level for a period of 22 weeks. During this period the pigs ate hardly more than was needed for maintenance, gained only 0.26 pound daily a head, and required 831 pounds of feed for each 100 pounds of gain produced. One died after 91 days. Its death was attributed to the feed. All the others became unthrifty in appearance.

After 22 weeks the cocoa bean oil meal was reduced to 10 per cent of the ration. No other deaths occurred and the harmful effects were less pronounced, but the ration was still unsatisfactory.

At the Vermont Station, Alpin fed cocoa bean oil meal at a 15 per cent level to 10-week-old pigs for 22 days. The pigs ate less than a normal amount of feed, scoured some, became unthrifty, and made a gain of only 1.3 pounds per head in the 22 days. Two died a few days after the feeding of cocoa bean oil meal had been discontinued. The cocoa bean oil meal, at a 15 per cent level, likewise proved unsatisfactory for brood sows.

According to the manufacturers, cocoa bean oil meal contains an average of about 0.75 per cent of caffein and a variable amount, but averaging approximately 2 per cent, of theobromine. In a Danish investigation Hansen found that the theobromine, which like the caffein is an alkaloid, was responsible for the harmful effect of cocoa bean oil meal on chickens rabbits, and mice.

TABLE 24.—Cocoa bean meal as an ingredient in the ration for pigs

	Corn Tankage Linseed meal Ground alfalfa Minerals	Corn Cocoa bean meal Tankage Ground alfalfa Minerals
Pigs at start	6	6
Initial weight per pig, lb	65.1	65.0
Pigs at close	6	5
Final weight per pig, lb	200.4	201.7
Average daily gain, lb	1.07	.49
Days required to gain 160 lb	150	329
Daily feed per pig, lb.:		
Corn	3.68	2.38
Cocoa bean meal	.....	.37
Tankage	.29	.17
Linseed meal	.14	.....
Ground alfalfa	.09	.06
Minerals	.06	.04
Total	4.26	3.02
Feed per 100-lb. gain, lb.:		
Corn	342.66	620.59
Cocoa bean meal	.....	75.57
Tankage	26.62	34.94
Linseed meal	13.31	.....
Ground alfalfa	7.93	12.41
Minerals	5.95	9.31
Total	**396.47**	**620.59**
Cost of feed per 100-lb. gain	$5.19	$7.75

CANE MOLASSES

Molasses as judged by its composition is a possible partial or complete substitute for corn. As reported in Bulletin 463, a sample of cane molasses was found to contain 20.3 per cent of water, 3.5 per cent of ash, 1.3 per cent of protein, and 74.9 per cent of carbohydrates. A sample of beet molasses contained 15.9 per cent of water, 4.4 per cent of ash, 8.7 per cent of protein, and 70.9 per cent of carbohydrates. The carbohydrates in molasses consist chiefly of sugar. As compared with other feeds, molasses is particularly high in iron.

Table 25 reports an experiment in which cane or blackstrap molasses was fed to fattening pigs with ground corn in the proportions of 20:80 and 40:60. The pigs were full-fed in dry lot and were given a half-pound of tankage daily a head in the two feeds.

As indicated by the consumption of smaller amounts of feed, molasses either decreased the palatability of the ration or else made it more difficult to consume. Averages of 0.9 and 1.9 pounds of molasses daily a head were fed. The pigs having molasses gained more slowly and made less gain per unit of feed than those without it.

With corn and tankage at the prices used, molasses showed a value of 80 cents a hundred pounds when making up 18.1 per cent of the ration and a value of 6 cents a hundred pounds when making up 37.8 per cent of the ration. These values were 73.7 and 5.2 per cent that of an equal weight of shelled corn.

Adding molasses to a mixture of the trio supplement and minerals and feeding this with shelled corn were tried in another experiment. At first it was used to make up 20 per cent of the mixture. The pigs ate so little of the supplement that after 8 weeks the molasses was reduced to 15 per cent of the mixture, and 2 weeks later an equal weight of ground corn was mixed and fed with the supplement, in order to get the pigs to take approximately the desired

TABLE 25.—Different amounts of molasses in rations for pigs

	Corn plus 0.5 lb. of tankage daily	Corn 80 Molasses 20 plus 0.5 lb. of tankage daily	Corn 60 Molasses 40 plus 0.5 lb. of tankage daily
Pigs at start	5	5	5
Initial weight per pig, lb.	95.5	95.2	99.0
Pigs at close	5	5	5
Final weight per pig, lb.	202.4	187.9	169.1
Average daily gain, lb.	**1.53**	**1.32**	**1.00**
Days required to gain 160 lb.	105	122	160
Daily feed per pig, lb.:			
Corn, ground	5.08	3.66	2.91
Molasses	.....	.92	1.94
Tankage	.50	.49	.49
Total	5.58	5.07	5.34
Feed per 100-lb. gain, lb.:			
Corn, ground	332.46	276.59	290.93
Molasses	.....	69.15	193.38
Tankage	32.65	37.22	49.22
Total	**365.11**	**382.96**	**533.52**
Feed per 100-lb. gain with molasses reduced to 10 per cent of moisture,* lb.	.....	375.04	511.39
Cost of feed per 100-lb. gain	$4.81	$5.26	$7.57
Value of molasses with shelled corn as 100 per cent	.....	73.7%	5.2%

*Assuming that the molasses contained 20.3 per cent of moisture, as did that the analysis for which is reported on page 2, Bulletin 463.

amount of supplement. The molasses averaged only 2.5 per cent of the total feed and could, therefore, hardly be regarded as having been used as a substitute for a part of the corn in the ration. The pigs fed molasses gained 0.2 pound less daily a head and required 77 pounds more feed per 100 pounds of gain than those without it. Fifteen and twenty per cent of molasses in the mixture made a gummy mass for the pigs to handle.

A little molasses is sometimes included in commercial supplements to act as a binder and prevent waste as a result of the feed's being blown about by the wind. An experiment is reported in Mimeograph Leaflet 130 of the Iowa Station in which 5 per cent of molasses was included in a mixed supplement. The molasses made up 1 per cent of the total feed. Both groups of pigs gained 1.4 pounds daily a head. Averages of 418 pounds of the ration containing molasses and 429 pounds of the one not containing it were required for each 100 pounds of gain produced.

Cane molasses was fed as a partial substitute for corn in three experiments at the Pennsylvania Station. These were reported in their Bulletin 215. Tankage was fed as a supplement. The rations contained an average of 22.3 per cent of molasses, or approximately 1 pound for every 3 pounds of corn. The pigs given molasses gained only 84 per cent as rapidly as those without it. With the molasses assumed to contain 20.3 per cent of water and reduced to a moisture basis of 10 per cent, one-tenth more of the feed containing it than of that without it was required per unit of gain produced. Considering only the feed per unit of gain, the molasses, as fed, was worth 44 per cent as much a pound as shelled corn in these Pennsylvania tests.

Experiments at the Hawaii, Minnesota, and Wisconsin Stations have shown molasses to have a relatively higher value when fed with oats or barley than when fed with corn.

DISTILLING AND BREWING BY-PRODUCTS

Grain by-products from the manufacture of alcoholic beverages are marketed for livestock feeding. These are sold wet for feeding near by or are dried for storing and shipping.

In the manufacture of distilled liquors the ground grain is mixed with water and malt and kept at a temperature at which the starch is converted into sugar. The sugar is then converted into alcohol by the action of yeast. After the alcohol is distilled off a watery residue known as distillery slop is left. This usually contains from 6 to 7 per cent of dry matter. If the wet grains are removed from the slop, the remaining liquor or strained slop contains around 4 per cent of dry matter or solids. The product obtained by evaporating the strained slop, that is, the mash liquor from which the alcohol and the wet grains have been removed, is known as distillers' corn, rye, or corn and rye, solubles, depending upon the grain from which it is derived. The wet grains and mash liquor may be dried together or separately. When dried separately, the two products may be marketed separately or recombined after the drying process.

Brewers' dried grains are the dried residue obtained in the manufacture of beer. This product is derived chiefly from barley rather than from corn or rye. Malt sprouts are the sprouts obtained from malted barley.

Table 26 gives the average amounts of water present and the composition of the dry matter contained in brewery and distillery by-products, as determined from data presented in Morrison's "Feeds and Feeding."

TABLE 26.—Composition of the dry matter of brewing and distilling by-products

	Number of samples	Water	Composition on a moisture-free basis				
			Protein	Fat	Fiber	Nitrogen-free extract	Ash
Brewers' wet grains	50	76.1	23.85	7.11	15.06	49.79	4.19
Brewers' dried grains (25 per cent or more of protein)	479	7.4	28.72	7.34	15.77	44.28	3.89
Distillery whole slop	9	93.8	30.65	9.68	8.06	46.77	4.84
Distillers' wet grains	4	77.6	19.64	6.70	11.16	59.37	3.13
Distillery strained slop	9	95.8	33.33	19.05	4.76	35.72	7.14
Corn distillers' dried grains	42	6.4	32.69	11.32	11.54	41.35	3.10
Rye distillers' dried grains	8	6.0	19.26	7.34	18.05	51.91	3.40
Malt sprouts	273	7.8	28.63	1.63	13.77	49.35	6.62

Corn distillers' dried grains.—Corn distillers' dried grains at the rate of 1 pound to every 3 of corn, or 22.5 per cent of the total ration, were fed in one experiment, along with a supplement of tankage, ground alfalfa, and minerals. Although this ration had a total protein content of 15.6 per cent, as compared with one of 13.5 per cent in the check ration, 3 per cent of tankage was left in the ration containing distillers' dried grains.

The consumption of 0.4 pound less feed daily a head would seem to indicate that corn distillers' dried grains were lacking somewhat in palatability for pigs. Distillers' grains are a trifle higher than oats in the amount of fiber contained. The check ration and the one of which distillers' grains were an ingredient contained approximately 3 and 6 per cent of fiber, respectively. The findings of a single trial are not conclusive but the inclusion of distillers' dried grains in the ration apparently reduced the gains per unit of feed to a greater extent than

TABLE 27.—Corn distillers' dried grains as a partial substitute for corn

	Corn 85.5 Tankage 7.5 Ground alfalfa 4.0 Minerals 3.0	Corn 67.5 Corn distillers' dried grains 22.5 Tankage 3.0 Ground alfalfa 4.0 Minerals 3.0
Pigs at start	10	10
Initial weight per pig, lb.	84.5	84.6
Pigs at close	10	10
Final weight per pig, lb.	203.9	206.5
Average daily gain, lb.	**1.31**	**.97**
Days required to gain 160 lb.	123	165
Daily feed per pig, lb.:		
Corn, ground	4.70	3.41
Corn distillers' dried grains		1.14
Tankage	.41	.15
Ground alfalfa	.22	.20
Minerals	.16	.15
Total	5.49	5.06
Feed per 100-lb. gain, lb.:		
Corn, ground	357.93	352.85
Corn distillers' dried grains		117.62
Tankage	31.40	15.68
Ground alfalfa	16.74	20.91
Minerals	12.56	15.68
Total	**418.63**	**522.74**
Cost of feed per 100-lb. gain	$5.49	$6.35
Value of corn distillers' dried grains with shelled corn as 100 per cent		23.7%

did the inclusion of an approximately equivalent amount of oats in other experiments. Perhaps a part of the relatively poor showing made by the ration containing the distillers' grains, which were a corn derivative, was not due to the increase in fiber but was a result of a failure of the distillers' grains to enhance the value of the corn ration through any supplemental action of their proteins or other nutrients.

Distillers' wet grains.—If it is assumed that the feeding value of the solids or dry matter in the wet grains is not greatly different from that of the solids in the dried grains, and that the findings of the test reported, which gave so seemingly low a value for the dried grains, are representative, wet grains containing around 77.6 per cent of water would have a value approximately 5.7 per cent that of an equal weight of corn.

Strained distillery slop.—In tests at the Kentucky Station, allowing strained distillery slop to settle for several hours and then removing a third or more of the clear liquid were found advisable. When settled slop equivalent to approximately two-thirds of the original weight was fed to fattening shotes at approximate rates of 2, 3, 4, and 6 pounds for each pound of corn and tankage, it showed values, on a basis of its original weight, of 2.5, 5.9, 5.1, and 3.8 per cent, respectively, or an average worth 4.3 per cent that a pound of shelled corn.

Whole distillery slop.—Since the dry matter in the whole slop, or that without the grains removed, is higher in fiber, considerably lower in fat, and slightly lower in protein, its feeding value probably does not exceed the average value of that in the strained slop. If it does not, whole distillery slop, which contains around 94 per cent of water, would have a value, when fed with corn and supplement, not exceeding 6.1 per cent that of an equal weight of corn.

Brewers' grains.—Brewers' grains are higher in fiber and less suitable for the feeding of swine than distillers' grains.

GARBAGE

Garbage varies greatly in composition and feeding value. That from public or institutional eating places is worth more than household garbage. In prosperous times, garbage has a higher value than in less prosperous times. The gains from a ton of garbage are said to range from as low as 24 to as high as 75 pounds. Garbage averages around 70 per cent moisture. The solids in it usually average from 15 to 25 per cent protein, 40 to 50 per cent carbohydrates, 20 to 25 per cent fat, and 10 to 15 per cent ash or minerals.

From a nutritional standpoint, cooking garbage is not advisable. Any harmful or distasteful substances present are spread throughout the feed by cooking. When raw garbage is fed, pigs have a better opportunity of selecting the edible and leaving the injurious, nonedible, or less suitable materials.

Reports of garbage-fed hogs' becoming crampy or developing rickets have been received. As a preventive of rickets, 5 to 7 pounds of minerals and 20 to 25 pounds of sun-cured ground alfalfa or 2 pounds of fish liver oil, or its equivalent in other vitamin D concentrate, daily for each 100 head of pigs may be mixed with their feed. At the University of Syracuse, pigs on rations of garbage and minerals with and without ground alfalfa gained 1.42 and 1.13 pounds daily a head, respectively. In another test there, the addition of cod-liver oil resulted in even faster gains than the addition of ground alfalfa.

SUMMARIZED DATA

For ready reference, the values, in relation to that of shelled corn, obtained for the complete and partial substitutes tried in the experiments reported are presented in table 28.

The chance that the figure obtained closely approximates the true value of a feed is not as great for those feeds that were fed in only one or two comparisons as for those that were fed in a larger number of comparisons and to a larger number of animals.

Whether the comparisons were made in dry lot or on pasture, or some under each set of conditions, is indicated. For the purpose of showing whether the growing, the fattening, or a large share of the entire period from weaning to market was included, the average initial and final weights are given. The pigs were self-fed or full-fed in all the experiments. Usually, in order to supply approximately equivalent amounts of total protein, the ingredients in a ration were mixed rather than fed separately. Some indication of the palatability of a substitute is furnished by the relative amounts of feed consumed by the pigs fed it and by those fed corn.

Only the differences in feed per unit of gain were taken into account in the relative values presented. Since costs other than feed are less in a short than in a longer feeding period, the days required by the pigs, at their average rate, to gain 160 pounds each, in relation to those required by the similar pigs fed corn, are shown.

Inasmuch as a partial substitute may be more satisfactory at one rate, or level, than at another, the average percentage included in the ration is shown. The ratio of the partial substitute to corn is likewise given.

Table 29 includes data from other stations as well as from Ohio and shows the values, in relation to that of shelled corn, obtained for various feeds that were used as complete substitutes for corn. The value obtained for a feed is

TABLE 28.—Worth of substitutes as compared with that of shelled corn

Ohio experiments

	Comparisons	Pigs on each ration	Pasture or dry lot	Average initial weight Lb.	Average final weight Lb.	Per cent in ration	Ratio to corn	Feed intake with corn ration as 100 per cent	Rate of gain with that of pigs fed corn as 100 per cent	Days to gain 160 lb. compared with pigs fed corn	Value a pound with shelled corn as 100 per cent
Complete substitutes											
Barley, ground	5	45	Dry lot	56	204	.....	.....	100.9	96.6	+ 4	100.3
Corn oil meal	1	7	Pasture	49	136	.....	.....	87.6	60.4	+89	69.5
Hominy feed, white	5	58	Both	57	194	.....	.....	90.8	88.9	+15	107.2
Oats, ground	8	75	Dry lot	53	199	.....	.....	107.7	87.3	+21	78.7
Oats, hulled	7	50	Dry lot	51	202	.....	.....	91.2	112.3	−16	135.8
Rye, ground	2	10	Both	83	207	.....	.....	96.5	86.3	+17	93.9
Wheat, ground	4	43	Dry lot	63	214	.....	.....	92.7	95.5	+ 5	107.6
Wheat, ground	4	43	Dry lot	63	141	.....	.....	93.5	100.9	.....	115.0
Wheat, ground	4	41	Dry lot	141	214	.....	.....	91.6	89.0	.....	101.0
Wheat middlings, flour	1	5	Dry lot	111	250	.....	.....	98.6	96.8	+ 4	102.0
Wheat middlings, standard	1	5	Dry lot	69	178	.....	.....	93.6	85.2	+22	90.2
Partial substitutes											
Cocoanut oil meal	1	6	Dry lot	65	233	15	1:5.1	105.5	104.3	− 6	115.3
Cocoanut oil meal	1	13	Dry lot	46	196	25	1:2.6	87.3	83.6	+25	102.3
Corn germ meal	3	24	Dry lot	53	189	20.7	1:3.2	90.4	93.3	+11	137.5*
Corn germ meal	1	6	Pasture	60	201	25	1:3	97.7	91.1	+12	91.3
Corn oil meal	1	7	Pasture	48	143	48	1:1	97.5	83.9	+27	74.3
Corn oil meal	2	20	Dry lot	51	197	21	1:3.1	90.8	89.4	+19	108.6*
Corn oil meal	1	4	Dry lot	129	281	14	1:6	102.5	103.6	− 3	135.7
Dried distillers' grains, corn	1	10	Dry lot	85	206	22.5	1:3	92.2	74.0	+42	23.7
Molasses, cane	1	5	Dry lot	95	188	18	1:4	90.9	86.3	+17	70.8
Oats, ground	6	61	Dry lot	58	204	22	1:2.9	107.6	102.7	− 4	89.4
Oats, ground	3	28	Pasture	61	203	19.5	1:3.9	104.6	94.9	+ 7	67.7
Oats, hulled	4	38	Dry lot	59	201	18.6	1:3.6	103.6	107.5	−10	137.2
Oat hulls	1	10	Dry lot	59	204	8	1:9.3	100.4	91.7	+12	Minus
Oat middlings	2	25	Dry lot	59	220	8	1:9.4	103.4	104.6	− 5	132.1
"Palmo Midds"	1	6	Dry lot	65	227	18	1:4	105.7	100.9	− 2	80.9
Rice polish	1	6	Dry lot	40	201	10	1:8.1	101.2	105.2	− 6	145.2
Wheat middlings, flour	4	28	Dry lot	77	212	19.5	1:3.8	99.6	96.9	+ 3	107.0

*Possibly somewhat high, because of the relatively poor performance of the check group in one test.

TABLE 29.—Worth of feeds, when used as complete substitutes, compared with that of shelled corn

	Number of comparisons	Pigs on each ration	Pasture or dry lot	Average initial weight Lb.	Average final weight Lb.	Approximate fiber in dry matter	Feed intake with corn ration as 100 per cent	Rate of gain with that of pigs fed corn as 100 per cent	Days to gain 160 lb. compared with pigs fed corn	Value a pound with shelled corn as 100 per cent
Bakery refuse, dried bread	4	30	Both	82	192	0.5	92.2	95.2	+ 7	104.6
Bakery refuse, crackers and cakes	4	29	Both	82	164	.9	94.0	75.5	+ 41	75.8
Barley, ground	19	166	Dry lot	61	214	6.3	103.0	94.1	+ 8	92.6
Barley, ground	13	130	Pasture	55	199	6.3	104.5	89.8	+ 13	86.4
Corn feed meal	2	17	Dry lot	112	229	3.4	101.1	102.6	− 3	105.6
Corn germ meal	2	17	Dry lot	113	199	9.6	76.0	75.4	+ 28	108.3
Corn oil meal	2	17	Dry lot	113	138	10.9	39.3	21.5	+317	2.1
Distillers' dried grains, corn	1	15	Pasture	67	100	11.5	52.5	49.0	+179	97.2
Garbage	3	23	Dry lot	93	224	2.9	128.6*	89.0	+ 16	25.3
Hominy feed	7	75	Dry lot	94	206	5.3	87.4	84.7	+ 20	97.9
Hominy feed	9	72	Pasture	61	208	5.3	99.5	95.1	+ 6	95.2
Millet seed, hay, ground	2	17	Dry lot	60	251	12.2	102.4	93.7	+ 7	88.2
Millet seed, hog, ground	4	34	Dry lot	66	260	10.1	107.5	103.2	− 3	97.1
Oats, ground	8	75	Dry lot	53	199	11.6	107.5	87.1	+ 21	78.7
Oats, ground	1	5	Pasture	43	130	11.6	80.7	68.3	+ 52	85.8
Oats, ground	4	31	Dry lot	138	208	11.6	91.6	61.8	+ 60	63.6
Oats, hulled	10	97	Dry lot	59	197	2.1	86.6	102.2	− 3	130.7
Oats, hulled	1	5	Pasture	43	182	2.1	114.3	109.2	− 9	96.1
Potatoes, dried, pressed	1	3	Dry lot	153	198	2.2	85.9	51.0	+ 98	47.1
Rice, brewers'	14	133	Both	88	200	.9	90.4	98.2	+ 2	110.3
Rice, rough	3	32	Dry lot	95	180	1.1	84.5	72.8	+ 35	68.0
Rice bran	6	40	Dry lot	103	184	14.3	87.3	75.4	+ 35	86.7
Rice polish	6	62	Both	69	135	3.3	83.4	78.5	+ 30	92.5
Rice polish	1	6	Dry lot	130	222	3.3	90.4	104.9	− 7	124.3
Rye, ground	6	41	Dry lot	66	165	2.6	75.2	63.9	+ 66	82.9
Rye, ground	8	69	Dry lot	122	203	2.6	91.0	77.7	+ 35	84.3
Rye, ground	1	5	Pasture	98	232	2.6	94.9	86.2	+ 15	92.4
Sorghums: Cane seed, ground	5	50	Dry lot	122	196	2.6	97.5	72.7	+ 39	75.2
Darso, grain, ground	4	30	Dry lot	125	232	3.1	117.9	98.9	+ 2	76.8
Feterita, grain, ground	1	5	Dry lot	116	156	2.5	100.5	94.4	+ 7	96.3
Kafir, grain, ground	6	46	Dry lot	116	214	2.6	108.8	100.2	0	93.8
Kaoliang, grain, ground	2	8	Dry lot	207	258	1.8	93.7	74.0	+ 44	78.1
Milo, grain, ground	3	30	Dry lot	114	216	2.5	96.1	88.3	+ 14	93.7
Wheat, ground	10	105	Dry lot	60	207	3.3	101.9	102.9	− 4	104.9
Wheat, ground	2	22	Pasture	65	192	3.3	113.3	110.4	− 13	98.1
Wheat, ground	10	161	Dry lot	107	230	3.3	104.5	100.6	− 1	98.1
Wheat middlings, flour	2	10	Both	76	237	4.9	108.2	103.1	− 4	98.5
Wheat middlings, standard	3	18	Both	54	155	7.6	96.5	82.5	+ 27	86.6

*With garbage reduced from assumed 70 per cent to 10 per cent moisture.

TABLE 30.—Worth of feeds, when used as partial substitutes, compared with shelled corn

	Number of comparisons	Pigs on each ration	Pasture or dry lot	Average initial weight Lb.	Average final weight Lb.	Approximate fiber in dry matter	Per cent in ration	Ratio to corn	Feed intake with corn ration as 100 per cent	Rate of gain with that of pigs fed corn as 100 per cent	Days to gain 160 lb. compared with pigs fed corn	Value a pound with shelled corn as 100 per cent
Beans, cull navy, cooked	4	32	Dry lot	104	202	4.0	31	1: 2.0	95.3	92.0	+ 10	107.7
Buckwheat middlings	2	19	Dry lot	73	204	8.3	24	1: 3.0	108.5	117.1	— 19	116.9
Cocoanut oil meal	1	6	Dry lot	65	233	11.5	15	1: 5.1	105.5	104.3	— 6	115.3
Cocoanut oil meal	1	13	Dry lot	46	196	11.5	25	1: 2.6	87.3	83.6	+ 25	102.3
Corn germ meal	2	14	Dry lot	113	220	9.6	50	1.1: 1	94.5	90.0	+ 10	108.1
Corn germ meal	3	24	Dry lot	53	189	9.6	21	1: 3.2	90.4	93.3	+ 11	137.5†
Corn oil meal	4	36	Dry lot	100	196	10.9	16	1: 5.1	93.9	87.5	+ 13	95.6
Corn oil meal	2	20	Dry lot	51	197	10.9	21	1: 3.1	90.8	89.4	+ 19	108.6†
Corn oil meal	6	47	Pasture	51	189	10.9	9	1:10.2	98.2	93.8	+ 8	84.0
Distillers' dried grains, corn	1	10	Dry lot	85	207	11.5	22	1: 3	92.2	74.0	+ 42	23.7
Distillery slop	1	10	Dry lot	113	.....	8.1	16	3.3: 1*	101.1	106.5	— 6	5.9
Garbage	3	25	Dry lot	75	269	2.9	62	5.1: 1	151.7*	119.2	— 21	20.9
Gluten feed, corn	2	11	Dry lot	52	225	7.8	11	1: 7.6	96.7	92.9	+ 8	75.2
Molasses, cane	5	41	Both	82	177	7.8	22	1: 2.9	92.7	84.9	+ 23	42.5
Oats, ground	20	278	Dry lot	64	206	11.6	22	1: 2.8	101.4	101.1	— 2	99.8
Oats, ground	8	63	Pasture	59	212	11.6	17	1: 4.6	102.2	97.1	+ 3	82.0
Oats, hulled	11	143	Dry lot	62	204	2.1	20	1: 3.3	100.1	106.4	— 8	147.2
Oats, hulled	5	37	Pasture	57	222	2.1	29	1: 1.8	105.2	107.3	— 7	109.7
Oat hulls, ground	1	10	Dry lot	59	204	32.7	8	1: 9.3	104.5	91.7	+ 12	Minus
Oat middlings	2	25	Dry lot	59	220	4.0	8	1: 9.4	103.4	104.6	— 5	132.1
"Palmo Midds"	2	13	Dry lot	82	216	8.0	16	1: 4.7	106.7	99.1	+ 1	93.2
"Palmo Midds"	4	34	Dry lot	83	173	8.0	43	1: 1.2	101.4	76.8	+ 41	49.5
Potatoes, cooked	4	29	Dry lot	117	189	1.9	34	3.1: 1	74.3	86.7	+ 18	28.2
Potatoes, raw	2	15	Dry lot	112	142	1.9	32	3.0: 1	36.5	38.3	+181	17.8
Rice, rough, ground	2	20	Dry lot	103	219	1.1	14	1: 5.6	101.8	95.6	+ 4	98.9
Rice polish	1	6	Dry lot	40	201	3.3	10	1: 8.1	101.2	105.2	— 6	145.2
Rice polish	1	10	Dry lot	140	238	3.3	51	1.25: 1	89.3	94.3	+ 6	115.4
Rice bran	2	20	Dry lot	57	189	14.3	28	1: 2.2	100.8	94.8	+ 7	81.7
Rye, ground	1	10	Dry lot	58	140	2.6	47	1: 1	104.7	107.9	— 18	95.7
Wheat, ground	3	26	Dry lot	88	179	3.3	46	1: 1	109.8	112.3	— 15	108.7
Wheat middlings, flour	8	61	Both	69	206	4.9	19	1: 3.9	106.0	103.3	— 4	103.0
Wheat middlings, standard	10	139	Both	64	212	7.6	19	1: 3.9	108.7	104.4	— 6	87.7

*Settled basis, or with one-third of water removed; per cent in ration given on 10 per cent moisture basis.
†Possibly somewhat high because of the relatively poor performance of the check group in one test.

likely to be more nearly accurate if a large than if a small number of comparisons and pigs is involved. Although no Ohio experiments were conducted with some of the feeds listed, a number of them are used in the State to a greater or less extent.

The data presented in table 30 showing the values in relation to that of shelled corn obtained for various feeds when they were fed as partial substitutes for corn, were likewise compiled from the findings of experiments carried on both at the Ohio and at other experiment stations.

SUMMARY

Hominy feed, in four dry-lot and one pasture experiment, had an average value 7 per cent greater than that of shelled corn.

According to a summary of the Ohio tests and 10 trials conducted elsewhere, the average worth of hominy feed was 98.2 per cent that of shelled corn. The consumption of more tankage with the hominy feed than with the corn and the inclusion of no material rich in vitamin A with the hominy feed in a few of the trials probably slightly lowered the value shown by the hominy feed.

Yellow hominy feed was worth 1.3 per cent more in one and 1.8 per cent more in another dry-lot trial than white hominy feed. Ground alfalfa was fed with each.

Corn oil meal was not satisfactory as a complete substitute for corn.

As determined from the feed required per unit of gain, the values obtained for corn oil meal in a 1:1 ratio with corn on pasture, and in a 1:3 ratio with corn in dry lot were 74 and 109 per cent that of shelled corn a pound, respectively. Feed consumption and the rate of growth were reduced by the inclusion of corn oil meal in the ration.

A higher value was obtained for corn oil meal when it was fed to shotes instead of younger pigs, and when it made up 14 instead of 21 per cent or more of the ration.

Corn germ meal differs from corn oil meal in that it is made by the dry rather than by the wet milling process. When fed with corn in a 1:3 ratio to pigs in dry lot, corn germ meal showed a value 37.5 per cent greater a pound than that of shelled corn. It slowed down the rapidity of the gains but less than corn oil meal.

In two direct dry-lot comparisons with 50-pound pigs in which each made up 21 per cent of their respective rations, corn germ meal was worth approximately a third more than corn oil meal.

Ground barley, in the five tests reported, was worth 0.3 per cent more than, that is, approximately the same a pound as, shelled corn. According to summaries including other data, or a total of 13 pasture and 19 dry-lot trials, the average worth of ground barley was 86.4 and 92.6 per cent that of shelled corn for pigs with and without pasture, respectively.

Mixing the barley and supplement was preferable to self-feeding them separately.

Barley infected with scab or fusarium blight was toxic or injurious to pigs.

Ground oats, when fed in place of all of the corn in eight dry-lot experiments, were worth 78.7 per cent as much a pound as shelled corn. The pigs fed oats reached an average weight of 200 pounds 3 weeks later than those fed corn. They grew rather than fattened and were thinner at a given weight than the corn-fed pigs.

The fat of oats-fed hogs was softer than that of corn-fed hogs of similar weight.

Ground oats, fed in six dry-lot trials at the average rate of approximately 1 pound to 3 of corn, or 1.5 pounds to 1 of supplement, were worth 89.4 per cent as much a pound as shelled corn. Pigs fed this quantity of oats were ready for market 4 days earlier than those without oats.

A summary of these and 14 similar tests at other stations showed ground oats, fed with corn in the average ratio of 1:2.8, not to have reduced the rate of growth, and to have an average worth 99.8 per cent, or practically the same a pound, as that of shelled corn.

For pigs on pasture ground oats, fed at the rate of 1 pound to every 4.6 pounds of corn, were worth 82 per cent as much a pound as shelled corn, or materially less than they were for pigs in dry lot.

When fed (1) with corn and (2) as the only grain, the average worth of ground oats was 33 and 22 per cent greater, respectively, than that of whole oats for shotes, and 27 and 21 per cent greater, respectively, than that of whole oats for growing and fattening pigs.

Hulled oats, fed as the only grain in seven dry-lot experiments, produced 11 per cent faster gains on 18 per cent less feed per unit of gain than corn. Disregarding the rapidity of the gains, hulled oats, as a complete substitute, were worth 36 per cent more a pound than shelled corn.

In four dry-lot trials in which they were fed at the average rate of 1 pound to 3.6 pounds of corn, or 1.3 pounds to each pound of supplement, hulled oats increased the rate and efficiency of the gains 7.5 and 3.5 per cent, respectively. In these tests, hulled oats as a partial substitute were worth 37 per cent more a pound than shelled corn. With the data of seven dry-lot trials at other stations included, the average ratio of hulled oats to corn was about the same, 1:3.3, but their average value was 47 per cent greater than that of shelled corn.

For pigs on pasture, according to five tests at other stations in which an average of 1 pound to 1.8 pounds of corn was fed, hulled oats were worth only 10 per cent more a pound than shelled corn.

Based on the average values obtained and on the assumption that the loss in original weight and the hulling charge would make hulled oats cost 64 per cent more than whole oats, hulled oats would not be an economical substitute for all of the corn for pigs in dry lot if the price of whole oats were in excess of 85 per cent that of corn a pound, or for more than a fourth of the corn if the price were in excess of 90 per cent that of corn.

In order to prevent confined pigs from becoming crampy or lame, that is, rachitic, it was necessary to fortify rations containing hulled oats as the only grain with ground alfalfa or some source of vitamin D and with a liberal supply of suitable minerals.

Hull-less oats corresponded closely to hulled oats in feeding value.

Ground rye, (1) in one Ohio trial and five trials at other stations with growing and fattening pigs in dry lot, (2) in eight trials at other stations with fattening shotes in dry lot, and (3) in the single pasture experiment reported, showed values 83, 84, and 92 per cent that of shelled corn, respectively. As named, the average amount of feed consumed daily a head was 75, 91, and 95 per cent that consumed by the pigs fed corn. The pigs fed rye required 66, 35, and 15 more days, respectively, than those fed corn to make an average gain of 160 pounds.

Rye, like the other small grains and white corn, is deficient in both vitamins A and D. Except in two of the experiments with shotes, no supplement other than tankage or tankage and minerals was fed. Probably rye would have shown a higher value in the dry-lot experiments if the rations in more of the tests had contained materials supplying vitamins A and D.

Perhaps mixing the supplement, particularly if it were well liked, and some corn or other palatable feed as well, with the rye would have increased the tastefulness and efficiency of the ration.

Rye is sometimes contaminated with ergot. In tests elsewhere, pigs did not eat enough ergot-infected rye to make satisfactory gains. Since ergot may cause abortion, caution to see that any rye fed to pregnant sows is free from ergot is necessary.

Ground wheat, in the four dry-lot experiments reported, was consumed at a somewhat slower rate and produced gains 4.5 per cent less rapidly than corn but was worth 7.6 per cent more a pound than shelled corn. In a total of 10 trials, a little more feed was taken and slightly faster gains were made by the pigs fed wheat than by those fed corn; and the average worth of the ground wheat was 4.9 per cent greater than that of shelled corn. In two trials on pasture, the value of ground wheat was 98.1 per cent that of shelled corn.

Wheat was worth more for growing pigs than for fattening shotes. During the early part of the four tests, or until the pigs averaged 140 pounds in weight, a value 15 per cent greater than that of shelled corn was shown by the ground wheat. For the fattening period, or from then on, its value was only 1 per cent greater. In 10 dry-lot tests with shotes averaging 107 pounds in initial weight, the value of ground wheat was 98.1 per cent that of shelled corn as against the value of 104.9 per cent obtained in the 10 trials with pigs started at an average weight of 60 pounds.

As determined from data from other sources, ground wheat was worth approximately 17 per cent more than whole wheat for shotes fed twice daily, but only 5 and 6 per cent more for shotes and for growing and fattening pigs that were self-fed.

Soaking wheat did not increase its feeding value.

Wheat middlings that were low in fiber, such as flour or white middlings, were worth more for pigs than those higher in fiber, such as standard middlings.

In single trials as complete substitutes for corn, flour middlings were worth approximately 102 and standard middlings, 90 per cent as much a pound as shelled corn. Including the data for one trial with flour middlings and two with standard middlings conducted elsewhere caused the two as named to show average values 98.5 and 86.6 per cent that a pound of shelled corn.

In eight tests including four at other stations, flour middlings used as a partial substitute and averaging 19 per cent of the ration had an average worth 3 per cent greater a pound than that of shelled corn. The average worth of standard middlings fed in the same manner in 10 experiments was 88 per cent that a pound of shelled corn.

"Palmo Midds", when constituting 18 per cent of the ration, had approximately the same value as that of middlings similar in quality to those used in their manufacture. A rather low value was obtained for "Palmo Midds" in a test in which they made up 25 per cent of the ration.

Cocoanut oil meal, at the rate of 15 per cent of the feed, did not increase the effectiveness of the ration but, because it replaced some of the relatively high-priced protein concentrate, as well as some of the corn, showed a value 15.3 per cent greater a pound than shelled corn. This was a higher value than was obtained when it was fed in larger quantities.

Fed in place of all the corn, with alfalfa, minerals, liquid skimmed milk at first and dried skimmed milk later, cocoanut oil meal was worth 92, 72, and 80 per cent as much a pound as shelled corn in the growing, in the fattening, and in the combined periods, respectively. The fiber or bulkiness of the cocoanut oil meal was doubtless largely responsible for its lower value during the fattening than during the growing period.

Cocoanut oil meal was not satisfactory as the only high-protein feed in the ration.

Rice polish, when making up 10 per cent of the feed, increased the rapidity of the gains and the gains per unit of feed of pigs in dry lot fed yellow corn, tankage, and minerals. Its value when thus fed was 45 per cent greater a pound than that of shelled corn.

Rice mixed bran, rice pearling cone bran, and rice polish each changed a fairly effective corn, linseed meal, and minerals ration into a ration of relatively high efficiency. The amounts fed averaged from 11 to 13 per cent of the total feed.

Rice mixed bran showed a value 5 per cent lower than that of rice polish. Rice pearling cone bran and rice polish were of approximately equal value.

With a supplement containing tankage, rice mixed bran was worth 78 per cent as much as rice polish.

Since rice oil has a softening effect on pork, if a ration containing a larger percentage of rice bran or rice polish were fed to pigs from weaning time until they were ready for market, there would be danger of the carcasses' lacking firmness.

Cocoa bean oil meal, fed at the rate of 15 per cent of the total feed, was toxic to pigs in dry lot. Investigations by others have indicated that alkaloids are responsible for its injurious effect.

Cane molasses, in five trials, four at other stations, in which it was fed to pigs carried from an average of 82 to 177 pounds in weight and in which the amount used was approximately 1 pound to 3 of corn, or 22 per cent of the total feed, was worth 42.5 per cent as much a pound as corn. The pigs receiving it required 23 days' more time to gain 160 pounds than those receiving no molasses. Tests elsewhere have indicated that molasses has a higher value for feeding with oats or barley than for feeding with corn.

Corn distillers' dried grains, fed at the rate of 1 pound to 3 of corn, or 22.5 per cent of the total ration, in one test, were worth approximately a fourth as much a pound as corn. This figure is presented merely as tentative until further data are available.

REFERENCES

BAKERY REFUSE

Grimes, M. F. 1927. Fattening rations for swine. Pa. Exp. Sta. Bull. 215.

BARLEY

Best, A. A., and W. L. Quayle. 1932. Swine feeding experiments. Wyo. State Exp. Farm, Mimeo. Leaflets.

Christensen, J. J., and H. C. H. Kernkamp. 1936. Studies on the toxicity of blighted barley to swine. Minn. Exp. Sta. Tech. Bull. 113.

Crampton, E. W. 1931. Barley vs. corn for market hogs. MacDonald College, McGill Univ., Que., Can. Tech. Bull. 9.

Edwards, W. E. J. 1930. Studies in swine feeding. Mich. Exp. Sta. Spec. Bull. 199.

Ferrin, E. F., and M. A. McCarty. 1928. Corn compared with barley. Minn. Exp. Sta. Mimeo. Cir. H-34.

————, W. H. Peters, and D. Johnson. 1930-1931. A comparison of five grains as hog feeds. Minn. Exp. Sta. Mimeo. Cirs. H-46 and H-48.

Freeman, V. A. 1932-1933. Value of grinding wheat and barley for feeding pigs. Mich. Exp. Sta. Mimeo. Cirs. 46 and 50.

Hale, F. 1931-1932. Swine feeding experiments. Texas Exp. Sta. Mimeo. Rep.

————. 1932. Whole vs. ground barley. Information to the author.

Joseph, W. E. 1924. Feeding pigs in dry lot. Mont. Exp. Sta. Bull. 169.

Kuhlman, A. H., and J. W. Wilson. 1925. Improving winter rations for pigs. S. Dak. Exp. Sta. Bull. 216.

Loeffel, W. J. 1930. Barley as a hog feed. Nebr. Exp. Sta. Bull. 251.

Maynard, E. J., H. B. Osland, and J. F. Brandon. 1932. Colorado dry land fattening rations for swine. Colo. Exp. Sta. Bull. 396.

Morton, G. E., H. B. Osland, and J. F. Brandon. 1932. Fattening rations for hogs. Colo. Exp. Sta. Press Bull. 81.

Oliver, A. W. 1931. Preparation of oats and barley for pigs. Oreg. Exp. Sta. Cir. 104.

Reed, F. H., and L. T. Chapman. 1925. Swine husbandry in Central Alberta. Dom. of Can. Dept. of Agr. Bull. 73, New Series.

Roche, B. H., and G. Bohstedt. 1930. Scabbed barley and oats and their effect on various classes of livestock. Am. Soc. of An. Prod., Rec. of Proc. of 23rd Ann. Mtg., pp. 219-222.

Thompson, C. P. 1923. Swine feeding investigations. Okla. Exp. Sta. Bull. 198.

Thompson, P. K., and W. L. Quayle. 1930. Swine feeding experiments. Wyo. State Exp. Farm Mimeo. Rep.

Wheeler, S. S., F. S. Hultz, and L. P. Reeve. 1930. The value of Wyoming small grains for fattening hogs. Wyo. Exp. Sta. Mimeo. Rep.

Wilson, J. W., and A. H. Kuhlman. 1921. Rations for pigs. S. Dak. Exp. Sta. Bull. 192.

———— and T. Wright. 1931. Barley as a fattening feed for cattle and swine in South Dakota. S. Dak. Exp. Sta. Bull. 262.

BEANS, CULL NAVY

Freeman, V. A., and W. E. J. Edwards. 1931. Cull navy beans for fattening pigs. Mich. Exp. Sta. Mimeo. Cir. 41.

BUCKWHEAT MIDDLINGS

Livesay, E. A., and E. O. Stillwater. 1928. Comparative tests of certain feeds in rations for pigs. W. Va. Exp. Sta. Bull. 213.

COCOA BEAN OIL MEAL

Alpin, R. D. 1927. Feeding cocoa meal to hogs. Vt. Exp. Sta. Bull. 271.

Hansen, C. H., and A. V. Lund. 1915. Ber K. Vet. og Landbohojskoles Lab. Landokonom. Forsög (Copenhagen) Vol. 89: pp. 26-37; 38-40; 90-103.

Robison, W. L. 1931. Improving corn and tankage for pigs not on pasture. Ohio Exp. Sta. Bull. 488, pp. 30-33.

COCOANUT OIL MEAL

Robison, W. L. 1931. Improving corn and tankage for pigs not on pasture. Ohio Exp. Sta. Bull. 488, pp. 30-33.

CORN FEED MEAL

Ashby, R. C. 1918. Feeding tests with fall pigs. Minn. Exp. Sta. Mimeo. Leaflet.

Skinner, J. H., and C. G. Starr. 1918. Swine feeding. Ind. Exp. Sta. Bull. 219, pp. 12-14.

CORN GERM MEAL

Skinner, J. H., and C. G. Starr. 1918. Swine feeding. Ind. Exp. Sta. Bull. 219.

CORN GLUTEN FEED

Culbertson, C. C., J. M. Evvard, W. E. Hammond, and C. F. Bassett. 1926. Corn gluten feed for fattening spring pigs. Iowa Exp. Sta. Leaflet 18.

Evvard, J. M., and C. C. Culbertson. 1925. Making three hundred pound fall pigs by April. Iowa Exp. Sta. Leaflet 11.

CORN OIL MEAL

Evvard, J. M., C. C. Culbertson, L. B. Sharp, and G. V. Glatfelter. 1920. Supplemental specialty feeds for pigs on rape pasture. Iowa Exp. Sta. Mimeo. Leaflet D-68.

———— and K. Dunn. 1917. Corn oil cake meal on bluegrass with corn. Iowa Exp. Sta. Mimeo. Leaflet.

Fargo, J. M., and G. Bohstedt. 1929. Protein supplements for growing and fattening pigs. Am. Soc. of An. Prod., Rec. of Proc. of 22nd Ann. Mtg., pp. 125-127.

Loeffel, W. J. 1925. Problems in winter fattening of Northwestern pigs. Nebr. Exp. Sta. Mimeo. Hog Cir. 224.

Skinner, J. H., and C. G. Starr. 1918. Swine feeding. Ind. Exp. Sta. Bull. 219.

DISTILLING AND BREWING BY-PRODUCTS

Morrison, F. B. 1936. Feeds and Feeding, Twentieth Edition.
Wilford, E. J. 1936. Distillery slop as a feed for hogs. Am. Soc. of An. Prod., Rec. of Proc. of 29th Ann. Mtg., pp. 106-110.

EMMER

Snyder, W. P. 1907. Corn, emmer, and barley for fattening hogs. Nebr. Exp. Sta. Bull. 99, p. 25.

GARBAGE

Ashbrook, F. G., and J. D. Debout. 1917. Disposal of city garbage by feeding to hogs. U. S. D. A. Cir. 80.
———— and A. Wilson. 1920. Feeding garbage to hogs. U. S. D. A. Farmers' Bull. 1133.
Barnett, E., and C. J. Goodell. 1923. Feeding garbage to hogs. Miss. Exp. Sta. Bull. 218, pp. 28-31.
Duck, R. W., and L. N. Gilmore. 1925. Garbage and minerals versus garbage, minerals, and vitamins for fattening pigs. Joseph Slocum Col. of Agr., Syracuse Univ. Mimeo. Leaflet.
———— and ————. 1927. Cod liver oil vs. alfalfa as a source of vitamins for garbage fed pigs. Joseph Slocum Col. of Agr., Syracuse Univ. Mimeo. Leaflet.
Hays, F. A. 1919. Swine production in Delaware. Del. Exp. Sta. Bull. 124, pp. 30-32.
Hultz, F. S., and L. P. Reeve. 1923. Garbage for fattening pigs. Wyo. Exp. Sta. Bull. 135.
Hunter, J. M. 1919. Garbage for pigs in dry lot. N. J. Exp. Sta. Ann. Rep., 1919, p. 109.
Miller, J. C. 1935. The value of garbage in the ration of growing and fattening pigs. Am. Soc. of An. Prod., Rec. of Proc. of 28th Ann. Mtg., pp. 101-104.
Thompson, C. P. 1919. Garbage compared with oats, corn, and barley. Okla. Exp. Sta. 28th Ann. Rep.
Williams, R. H. 1919. Ariz. Exp. Sta. Ann. Rep., 1919, pp. 424-425.
————. 1922. Ariz. Exp. Sta. Ann. Rep., 1922, pp. 211-213.
———— and E. B. Stanley. 1923. Ariz. Exp. Sta. Ann. Rep., 1923, pp. 467-470.

HOMINY FEED

Eastwood, G. R. 1914. Substitutes for corn in rations for fattening swine. Ohio Exp. Sta. Bull. 268.
Evvard, J. M., C. C. Culbertson, L. B. Sharp, and G. V. Glatfelter. 1920. Basal specialty feeds for pigs on rape pasture. Iowa Exp. Sta. Mimeo. Leaflet D-67.
———— and R. Dunn. 1917-1919. Corn substitutes on bluegrass and rape pastures. Iowa Exp. Sta. Mimeo. Leaflets.
Gramlich, H. J. 1920. Summer hog feeding. Nebr. Exp. Sta. Bull. 176.
———— and E. L. Jenkins. 1920. Experimental hog feeding. Nebr. Exp. Sta. Bull. 175.

———— and W. J. Loeffel. Nebr. Exp. Sta. Mimeo. Leaflet.
Scott, E. L. 1930. The influence of the growth and fattening process on the quantity and quality of meat yielded by swine. Ind. Exp. Sta. Bull. 340, pp. 24-25.
Skinner, J. H., and F. G. King. 1912. Hominy feed for fattening hogs. Ind. Exp. Sta. Bull. 158.
———— and C. G. Starr. 1918. Swine feeding. Ind. Exp. Sta. Bull. 219.

MILLET SEED

Maynard, E. J., H. B. Osland, and J. F. Brandon. 1932. Colorado dry land fattening rations for swine. Colo. Exp. Sta. Bull. 396.
Morton, G. E., H. B. Osland, and J. F. Brandon. 1932. Fattening rations for hogs Colo. Exp. Sta. Press Bull. 81.

MOLASSES

Barnett, E., and C. J. Goodell. 1923. Grazing and feeding trials with hogs. Miss. Exp. Sta. Bull. 218.
Bohstedt, G., B. H. Roche, J. M. Fargo, I. W. Rupel, J. G. Fuller, and P. E. Newman. 1934-1935. Molasses for pigs. Wis. Exp. Sta. Bull. 428, p. 18, and Bull. 430, p. 119.
Burns, J. C. 1910. Hog feeding experiments. Texas Exp. Sta. Bull. 131.
Ferrin, E. F. 1936. Molasses as a substitute for grains. Minn. Exp. Sta. Mimeo. Leaflet H-69.
————. 1937. Cane molasses in hog rations. Minn. Exp. Sta. Mimeo. Leaflet H-70.
Fjeldsted, E. G., and E. L. Potter. 1919. Oreg. Exp. Sta. Bull. 165.
Grimes, M. F. 1927. Fattening rations for swine. Pa. Exp. Sta. Bull. 215.
Hackedorn, H., and J. Sotola. 1922. Hog feeding experiments. Wash. Exp. Sta. Bull. 169.
Henke, L. A. 1933. Cane molasses as a supplement to fattening rations for swine. Univ. of Hawaii Bull. 69.

OATS AND OAT PRODUCTS

Carroll, W. E. 1933. Oats as a feed for swine. Ill. Exp. Sta. Cir. 414.
Culbertson, C. C., J. M. Evvard, W. E. Hammond, and C. F. Bassett. 1926. Oat feed for fattening spring pigs. Iowa Exp. Sta. Leaflet 18.
————, ————, and ————. 1931. Modification of the "Big 10" supplement for fattening fall pigs in dry lot. Iowa Exp. Sta. Mimeo. Leaflet 133.
———— and W. E. Hammond. 1931. Supplement modifications for fattening spring pigs. Iowa Exp. Sta. Mimeo. Leaflet 134.
Dungan, G. H., and W. L. Burlison. 1929. Varieties of oats for Illinois. Ill. Exp. Sta. Bull. 339.
Eastwood, G. R. 1914. Substitutes for corn in rations for fattening swine. Ohio Exp. Sta. Bull. 268.
Evvard, J. M., C. C. Culbertson, W. E. Hammond, and C. F. Bassett. 1926. Corn belt rations for fattening spring pigs on pasture and in dry lot. Iowa Exp. Sta. Leaflet 19.

————, ————, ————, and ————. 1927. Oat products for fattening spring pigs. Iowa Exp. Sta. Leaflet 121.
————, ————, ————, and ————. 1928. Oat preparations for self fed pigs on rape pasture. Iowa Exp. Sta. Leaflet 125.
————, ————, ————, and G. W. Wallace. 1926. The utilization of oats in the growing and fattening of spring pigs. Iowa Exp. Sta. Leaflet 15.
Ferrin, E. F. 1928. Summary of swine feeding experiments. 1921-1928. Univ. of Minn. Exten. Pamphlet 3.
———— and M. A. McCarty. 1927. What should be the proportion of corn to oats in rations for growing pigs? Minn. Exp. Sta. Mimeo. Leaflet H-30.
————, W. H. Peters, and D. Johnson. 1930-1931. A comparison of five grains as hog feeds. Minn. Exp. Sta. Mimeo. Cirs. H-46 and H-48.
Freeman, V. A. 1931. Feeding spring pigs on rape pasture. Mich. Exp. Sta. Mimeo. Leaflet.
Lathrop, A. W., and G. Bohstedt. 1936. Utilization of oat mill feed by growing, fattening swine in dry lot. Am. Soc. of An. Prod., Rec. of Proc. of 29th Ann. Mtg., pp. 82-87.
McCarty, M. A. 1930-1931. Pa. Exp. Sta. Bulls. 258 and 266.
Rice, J. B., and R. J. Laible. 1919. Oats in addition to a corn and tankage ration. Ill. Exp. Sta. Mimeo. Leaflet.
Robison, W. L. 1928. Oats for growing and fattening pigs. Ohio Exp. Sta. Bimo. Bull. 134, Vol. XIII, No. 5, pp. 174-178.
Thompson, C. P. 1923. Swine feeding investigations. Okla. Exp. Sta. Bull. 198.
Vestal, C. M. 1929. Different proportions of corn and oats for fattening hogs. Ind. Exp. Sta. Mimeo. Leaflet.
————. 1930. Grinding or hulling oats for hogs. Ind. Exp. Sta. Mimeo. Leaflet.
Weaver, L. A. 1927. Pastures for hogs. Mo. Exp. Sta. Bull. 247, p. 36.

"PALMO MIDDS"

Grimes, M. F. 1927. Fattening rations for swine. Pa. Exp. Sta. Bull. 215.
Robison, W. L. 1931. Improving corn and tankage for pigs not on pasture. Ohio Exp. Sta. Bull. 488, pp. 30-33.
Skinner, J. H., and C. G. Starr. 1918. Swine feeding. Ind. Exp. Sta. Bull. 219.

POTATOES

Ashbrook, F. G., and R. E. Gongwer. 1917. Feeding dried pressed potatoes to swine. U. S. D. A. Bull. 596.
Fjeldsted, E. J., and E. L. Potter. 1919. Finishing pigs for market. Oreg. Exp. Sta. Bull. 165, p. 12.
Grisdale, J. H. 1926. Ottawa, Can. Exp. Farms Bull. 57.
Osland, H. B., and G. E. Morton. 1931. Field peas for fattening pigs. Colo. Exp. Sta. Bull. 381.
Swier, G. B. 1934. Raw vs. cooked potatoes for fattening hogs. Wash. Exp. Sta. Bull. 291, p. 20.
Wilson, J. W., and A. H. Kuhlman. 1924. Potatoes as a feed for fattening pigs. S. Dak. Exp. Sta. Bull. 209.

RICE AND RICE BY-PRODUCTS

Barnett, E., and C. J. Goodell. 1923. Grazing and feeding trials with hogs. Miss. Exp. Sta. Bull. 218.

Bray, C. I. 1933. Rice bran for fattening hogs. La. Exp. Sta. Mimeo. Leaflet.

Dvorachek, H. E. 1916. Fattening swine on rice by-products. Ark. Exp. Sta. Bull. 128.

Fraps, G. S. 1916. The composition of rice and its by-products. Texas Exp. Sta. Bull. 191.

Hughes, E. H. 1927. Rice and rice by-products as feed for fattening swine. Calif. Exp. Sta. Bull. 420.

Martin, E. 1934. A study of the use of rice by-products for feeding swine and effects on quality of pork. Ark. Exp. Sta. Bull. 303.

Warren, G. R. 1923. Rice bran and rice polish for growing and fattening pigs. Texas Exp. Sta. Bull. 313.

RYE

Brown, G. A., W. E. J. Edwards, and V. A. Freeman. 1937. Comparative value of home grown grains. Mich. Exp. Sta. Mimeo. Leaflet.

Edwards, W. E. J., and G. A. Brown. 1925. Rye for fattening hogs. Mich. Exp. Sta. Quart. Bull., Vol. 8, No. 2, pp. 76-78.

Ferrin, E. F. 1925. Feeding rye to pigs. Am. Soc. of An. Prod., Rec. of Proc. of 18th Ann. Mtg., pp. 79-83.

————. 1931. The best methods of feeding rye. Minn. Exp. Sta. Mimeo. Leaflet H-50.

———— and M. A. McCarty. 1928. Feeding rye to hogs. Minn. Exp. Sta. Mimeo. Leaflet H-36.

————, W. H. Peters, and D. Johnson. 1930-1931. Comparison of five grains as hog feed. Minn. Exp. Sta. Mimeo. Leaflets H-46 and H-48.

———— and H. B. Winchester. 1921. Rye as a substitute for corn. Kans. Exp. Sta. Cir. 89, Part III.

Hays, F. A. 1919. Swine production in Delaware. Del. Exp. Sta. Bull. 124, pp. 32-37.

Johnson, D. W., and L. S. Palmer. 1934. The nutritive properties of protein, vitamin B and G and the germ in rye. Jour. Agr. Res., Vol. 49, No. 2, pp. 169-181.

———— and ————. 1935. Ergot as a factor in the nutritive value of rye for rats and swine. Jour. of Agr. Res., Vol. 50, No. 1, pp. 39-45.

McCarty, M. A. 1933. Supplements to corn in rations for swine. Pa. Exp. Sta. Bull. 293, p. 15.

Potter, E. L. 1926. Rye for hogs. Oreg. Exp. Sta. Bien. Rep., 1924-1926, p. 37.

Sackville, J. P., and R. D. Sinclair. 1924. Pure rye vs. ergoty rye. Univ. of Alta. Can. Mimeo. Leaflet.

Snyder, W. P. 1915. Pork production. Nebr. Exp. Sta. Bull. 147, Lim. Ed., p. 44.

Vinke, L., and B. Bergstedt. 1934. Small grains and supplements for fattening fall pigs. Mont. Exp. Sta. Bull. 284.

Wheeler, S. S., F. S. Hultz, and L. P. Reeve. 1930. The value of Wyoming small grains for fattening hogs. Wyo. Exp. Sta. Mimeo. Leaflet.

Wilson, J. W., and T. Wright. 1932. Rye as a fattening feed for cattle and swine in South Dakota. S. Dak. Exp. Sta. Bull. 271.

SORGHUMS

Bell, F. W., H. B. Winchester, and H. W. Marston. 1923. Corn versus cane seed for fattening pigs. Kans. Exp. Sta. Cir. 98, Part II.

Dvorachek, H. F., and H. A. Sandhouse. 1917. Sorghum grains versus corn for fattening swine. Ark. Exp. Sta. Cir. 34.

Ferrin, E. F., and H. B. Winchester. 1921. Grain sorghums compared with corn. Kans. Exp. Sta. Cir. 89, Part IV.

Malone, J. S. 1918. Corn, kafir, and darso as fattening feeds for pigs. Okla. Exp. Sta. Bull. 120.

Snyder, W. P. 1912. Fattening hogs in Nebraska. Nebr. Exp. Sta. Bull. 124, Lim. Ed.

Thompson, C. P. 1923. Swine feeding investigations. Okla. Exp. Sta. Bull. 198.

————. 1925. Preparation of kafir corn for fattening hogs. Am. Soc. of An. Prod., Rec. of Proc. of 18th Ann. Mtg., pp. 83-84.

Thompson, J. I., and E. C. Voorhies. 1922. Hog feeding experiments. Calif. Exp. Sta. Bull. 342.

Warren, G. R. 1923. Swine feeding experiments. Texas Exp. Sta. Bull. 305.

Weber, A. D., B. M. Anderson, and H. W. Marston. 1928. Swine feeding investigations, 1923 to 1926. Kans. Exp. Sta. Cir. 138.

Wheeler, G. C. 1913. Hog feeding. Kans. Exp. Sta. Bull. 192.

Wilson, J. W. 1914. Kaoliang for pigs. S. Dak. Exp. Sta. Bull. 157.

SPELT

Thompson, P. K. 1931. Hog feeding experiment. Wyo. Exp. Sta. Mimeo. Leaflet.

WHEAT

Aubel, C. E., and W. E. Connell. 1932. Corn versus wheat for spring pigs on alfalfa pasture. Kans. Exp. Sta. Mimeo. Leaflet.

Best, C. A., and W. L. Quayle. 1930. Hog feeding experiment. Wyo. Exp. Sta. Mimeo. Leaflet.

Bliss, R. K., and C. B. Lee. 1914. Ground wheat versus whole wheat for fattening pigs. Nebr. Exp. Sta. Bull. 144.

Carmichael, B. E. 1932. Feeding wheat to fattening hogs. Md. Exp. Sta. Bull. 336.

Eastwood, G. R. 1914. Substitutes for corn in rations for fattening swine. Ohio Exp. Sta. Bull. 268.

Ferrin, E. F., and D. Johnson. 1930. Substituting wheat for corn. Minn. Exp. Sta. Mimeo. Leaflet H-45.

————, W. H. Peters, and D. Johnson. 1931. A comparison of five grains as hog feeds. Minn. Exp. Sta. Mimeo. Leaflet H-48.

Freeman, V. A. 1930. Market surplus wheat as pork. Mich. Exp. Sta. Quart. Bull., Vol. XIII, No. 3, pp. 107-108.

————. 1932-1933. Value of grinding wheat and barley for feeding pigs. Mich. Exp. Sta. Mimeo. Cirs. 46 and 50.

Good, E. S., and W. V. Smith. 1915. The value of wheat as a feed for swine. Ky. Exp. Sta. Bull. 190.

Hale, F. 1931. Swine experiments. Tex. Exp. Sta. Mimeo. Leaflet.

————. 1932. Whole wheat versus ground wheat for fattening hogs. Tex. Exp. Sta. Mimeo. Leaflet.

Loeffel, W. J. 1931. Wheat for fattening hogs. Nebr. Exp. Sta. Bull. 261.
McCarty, M. A. 1929. A comparison of corn, barley, and wheat for fattening feeder pigs in dry lot. Pa. Exp. Sta. Mimeo. Leaflet.
Morton, G. E., H. B. Osland, and J. F. Brandon. 1932. Fattening rations for hogs. Colo. Exp. Sta. Press Bull. 81.
Peters, W. H., E. F. Ferrin, and D. Johnson. 1930. The five grains as hog feeds. Minn. Exp. Sta. Mimeo. Leaflet H-46.
Plumb, C. S., and W. B. Anderson. 1897. Wheat and corn as food for pigs. Ind. Exp. Sta. Bull. 67.
Thompson, C. P. 1927. Preparation of kafir corn and wheat for swine feeding. Okla. Exp. Sta. Bull. 165.
————. 1931. How to prepare wheat for feeding hogs. Okla. Exp. Sta. Mimeo. Leaflet.
————. 1935. Preparation of wheat for fattening hogs. Okla. Exp. Sta. Mimeo. Leaflet.
Thompson, P. K., and W. L. Quayle. 1931-1932. Hog feeding experiments. Wyo. Exp. Sta. Mimeo. Leaflets.
Vestal, C. M. 1930. Wheat as a substitute for corn in fattening hogs. Ind. Exp. Sta. Mimeo. Leaflet.
Weaver, L. A. 1915. Feeding wheat to fattening swine. Mo. Exp. Sta. Bull. 136.
Wilson, W. J., and T. Wright. 1932. Fattening summer pigs on South Dakota grains. S. Dak. Exp. Sta. Mimeo. Leaflet.

WHEAT MIDDLINGS

Eastwood, G. R. 1914. Substitutes for corn in rations for fattening swine. Ohio Exp. Sta. Bull. 268.
Evvard, J. M., and R. Dunn. 1917. Corn substitutes on bluegrass and rape pastures. Iowa Exp. Sta. Mimeo. Leaflet.
———— et al. 1919. Commercial feeds for pigs on rape. Iowa Exp. Sta. Mimeo. Leaflet.
Fargo, J. M., and G. Bohstedt. 1929. Protein supplements for growing and fattening pigs. Am. Soc. of An. Prod., Rec. of Proc. of 22nd Ann. Mtg., pp. 125-127.
Ferrin, E. F., and M. A. McCarty. 1925. A comparison of wheat by-products for growing pigs. Minn. Exp. Sta. Bull. 219.
Grimes, M. F. 1927. Fattening rations for swine. Pa. Exp. Sta. Bull. 215.
Loeffel, W. J. 1925. Problems in winter fattening of Northwestern pigs. Nebr. Exp. Sta. Mimeo. Hog Cir. 224.
————. 1926. Protein and supplementary mixtures for fattening fall pigs. Nebr. Exp. Sta. Mimeo. Hog Cir. 233.
————. 1930. Pig feeding investigations on forage. Nebr. Exp. Sta. Mimeo. Hog Cir. 233.
————. 1930. The efficiency of protein supplementary mixtures for pasture feeding. Nebr. Exp. Sta. Mimeo. Hog Cir.
McCampbell, C. W., E. F. Ferrin, and H. B. Winchester. 1919. Swine feeding investigations. Kans. Exp. Sta. Cir. 78.
Rice, J. B. 1924. Feeding pigs on pasture. Ill. Exp. Sta. Bull. 247.
———— and R. J. Laible. 1917-1919. Middlings as an additional feed to a corn and tankage ration. Ill. Exp. Sta. Mimeo. Leaflets.
Robison, W. L. 1922. Self feeding swine. Ohio Exp. Sta. Bull. 355.

Weaver, L. A. 1927. Pastures for hogs. Mo. Exp. Sta. Bull. 247, pp. 36-37.
Wheeler, G. C., and T. R. H. Wright. 1913. Hog feeding. Kans. Exp. Sta. Bull. 192.

COMPARISONS OF EAR AND GROUND WITH SHELLED CORN

Aubel, C. E., and W. E. Connell. 1934. Swine feeding investigations, Exp. II, Preparation of grain. Kans. Exp. Sta. Mimeo. Leaflet.
Bohstedt, G., B. H. Koche, J. M. Fargo, I. W. Rupel, and F. E. Duffee. 1931. The effect of the fineness of grinding corn and barley for pigs and dairy cattle. Am. Soc. of An. Prod., Rec. of Proc. of 24th Ann. Mtg., pp. 277-281.
Eastwood, G. R. 1910, 1911, and 1912. Preparation of corn. Ohio Exp. Sta. Unpub. data.
Kennedy, W. J., and E. F. Robbins. 1909. Preparation of corn for hogs. Iowa Exp. Sta. Bull. 106.
King, F. G. 1913. The effect of preparation of corn on hogs of different sizes. Am. Soc. of An. Prod., Rec. of Proc. of Sixth Ann. Mtg., pp. 22-31.
McCarty, M. A., J. E. Nicholas, and T. B. Keith. 1936. Grinding corn for swine. Pa. Exp. Sta. Bull. 326.
Robison, W. L. 1935. Feeding pigs on forage. Ohio Exp. Sta. Bull. 552, pp. 47-51.